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JUL 1 0 1933

Heating · Piping and Air Conditioning

Heating and Ventilating Features of
The New Cincinnati Union Terminal

High-Pressure Steam Line Electric Welded

Control Cuts Heating Steam 22%

Filtered Air Relieves Hay Fever

Journal Section of the A. S. H. V. E.

Design
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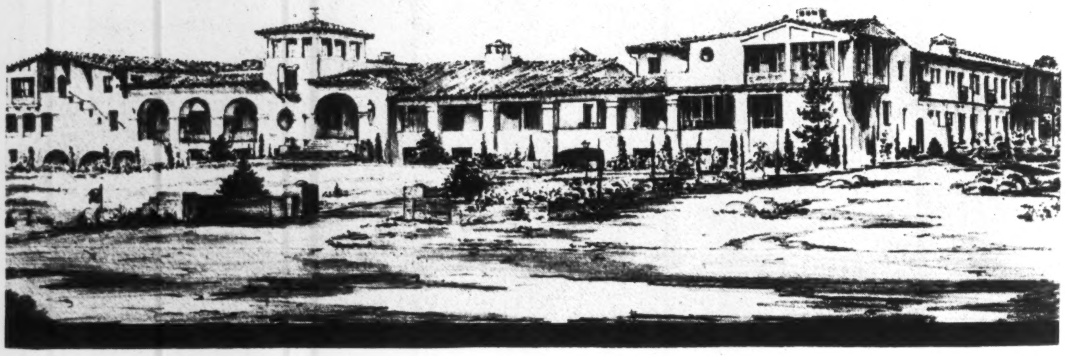
Industry and
rge Buildings

July, 1933

FROM MAINE . . TO . . . . CALIFORNIA

The MODUTROL SYSTEM of TEMPERATURE CONTROL



New England Telephone and Telegraph Company Building, Portland, Me.; Densmore, LeClear & Robbins, Architects, Boston

MODUTROL SYSTEM EQUIPPED

Eastern Star Home, Los Angeles, Calif., Mosier & Son, Architects

THE continent over, the Modutrol System of controlling heating, ventilating, and air conditioning has earned the acclaim and acceptance of fact-finding engineers, architects and building operators . . . Its ease of installation, flexibility of application, low original cost, economical operation, negligible cost, and its inherent accuracy and control qualities, make it the most advantageous control system available. The Modutrol System is tailor made to your needs, for old buildings or new, large or small. Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave So., Minneapolis, Minn. Branch offices and distributors in all principal cities.

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Heating • Piping and Air Conditioning

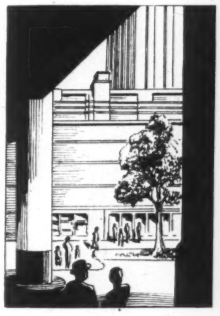
THE EDITOR'S PAGE

MANY timely articles will be found in this issue: they contain up-to-date information about heating, piping, and air conditioning for industrial plants and large buildings. For instance, there's the description of the heating and ventilating features of Cincinnati's new Union Terminal, opened last April, long a project in Cincinnati's development. The new Terminal has attracted much attention, is said to be the "last word." Among its features is an air-conditioned theater, where passengers may enjoy movies while waiting for trains. Heating engineers will be interested in the way the six-story double-window—great half-circle—is heated.

STARTING on page 354, Robert Daniels describes in detail the construction of a piping system for 400-lb, 750-F steam which is electric-arc-welded throughout. Informative and helpful data are included which will be found of value by others concerned with similar industrial steam piping systems. . . . Samuel Kameros, in his paper on the graphic solution of some common pipe bends (page 342) presents a series of charts (with the necessary information for their use) which many will find time- and trouble-saving. Considerable attention is being devoted these days to simplification of the design of piping systems to allow for flexibility.

ESTABLISHING itself more and more each day as indispensable to a modern building, a necessity in industrial processes of many kinds, air conditioning continues to attract the increasing attention of the engineer and the general public. At the Chicago World's Fair, air-conditioned buildings, restaurants, and exhibits, have proved their popularity in the June heat wave; the article on page 360 describes some of these jobs. . . . The results of research on filtered air for the relief of hay-fever and pollen-asthma sufferers are given by Dr. William H. Welker and two of his colleagues at the college of medicine of the *University of Illinois* in a paper starting on page 348. . . . A representative installation of air conditioning for ripening of fruits is described in a short article starting on page 352.

JUST what the term "air conditioning" means has been the subject of a number of inquiries received recently. In this connection the brief comments on page 70 (back advertising section) of this issue will be of interest. Further clarifying of the meaning of "air conditioning" appears to be of importance.



Selected for the new plant of The Cincinnati Times-Star

DETROIT STOKERS

insure economical boiler operation

THE CINCINNATI TIMES-STAR BUILDING
Samuel Hannaford & Sons, Cincinnati, Architects and Engineers

Newspaper publishers, like manufacturers of all other products and services, have had to cut their operating costs to the limit. Today, as never before, a premium is placed on economy. This situation is chiefly responsible for the selection of Detroit Stokers for the recently completed plant of The Cincinnati Times-Star.

Detroit Stokers save fuel and labor. They eliminate objectionable smoke and are thoroughly dependable. They efficiently burn all grades of bituminous coal without expensive preparation and are very responsive to changes in load.

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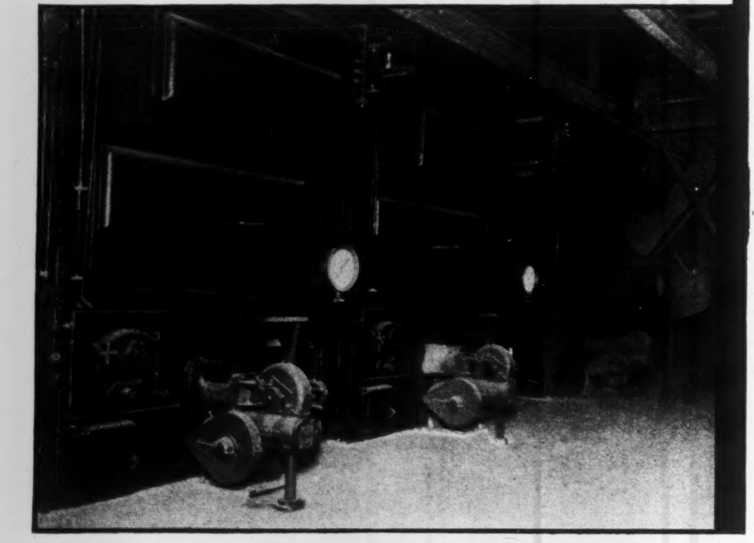

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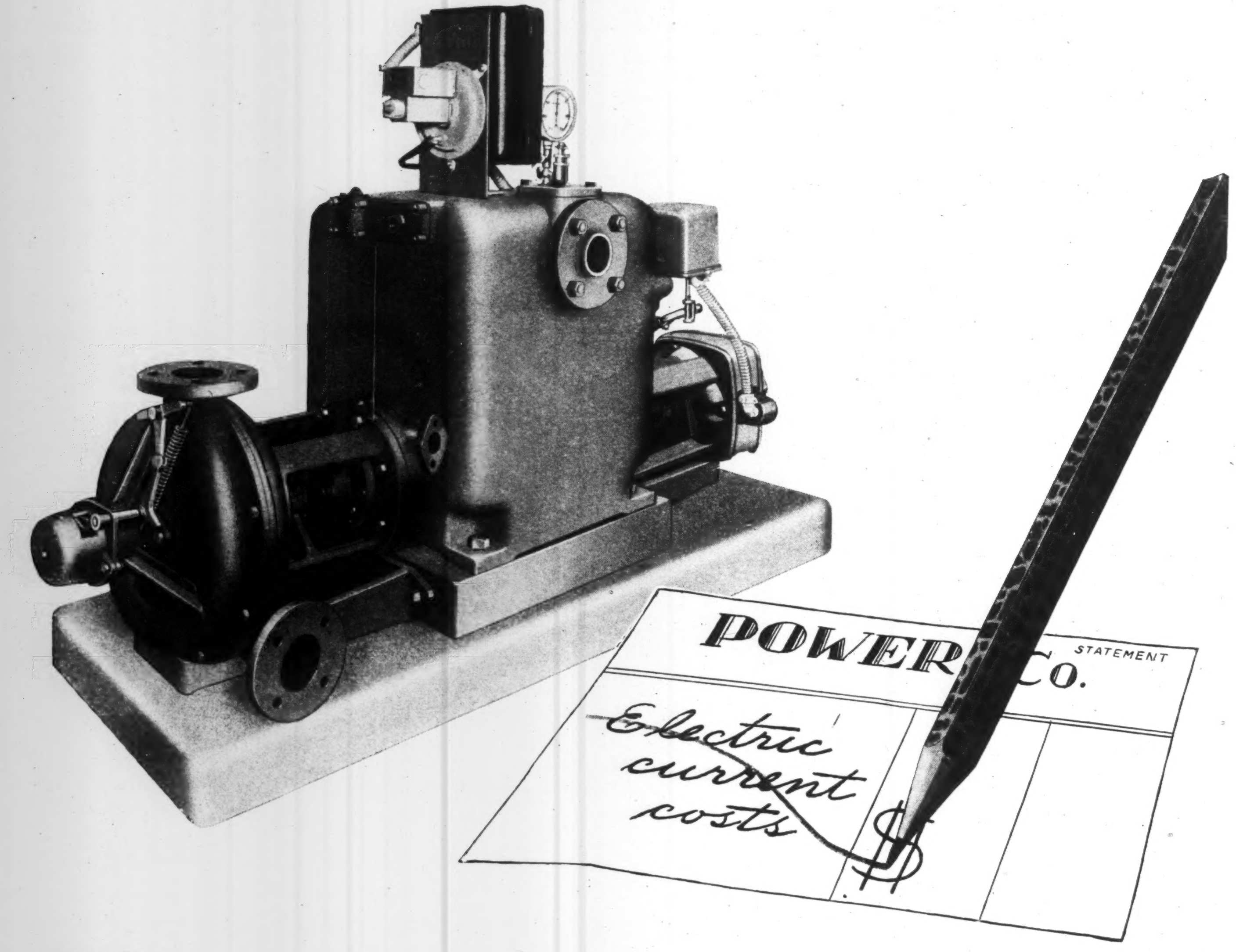


Why not cross out this expense?

Why not eliminate the one largest cost item in the operation of a return line heating pump, the electric current? The Jennings Vapor Turbine operates on steam directly from your heating mains, and returns that steam to the heating system with little heat loss.

This remarkable pump is driven by a newly developed vapor turbine which functions on a differential of only 5″ of mercury, and on any type of vacuum heating system, regardless of type of steam control. It is equally efficient on low pressure steam, high pressure steam thru reducing valve, or on street steam. It makes no difference whether the system is run above or below atmosphere, because the turbine functions on the difference between the inlet and exhaust, not on a given pressure above atmosphere.

But this saving in operating cost is not the only advantage offered by the new Vapor Turbine Jennings Heating Pump. This equipment gives you safety in your heating system. It is independent of possible current failures. It functions as long as there is steam in the heating system, assuring constant and reliable vacuum and boiler return.

Further, the fact that its operation is continuous means that the system is kept at the maximum of its operating efficiency at all times.

There are other points about this pump that it will pay you to investigate. They are covered in Bulletin 203. We need only your name and address to send you a copy.

THE NASH ENGINEERING COMPANY
SOUTH NORWALK, CONNECTICUT

Heating·Piping and Air Conditioning

Vol. 5, No. 7 • July, 1933

OPENED IN APRIL the new Cincinnati Union Terminal is said to be the last word in large railroad passenger terminals . . . . An air-conditioned theater—where waiting passengers may view motion pictures—is among its features . . . . Unusual in several respects are the heating and ventilating systems.

New Terminal Has Novel Features

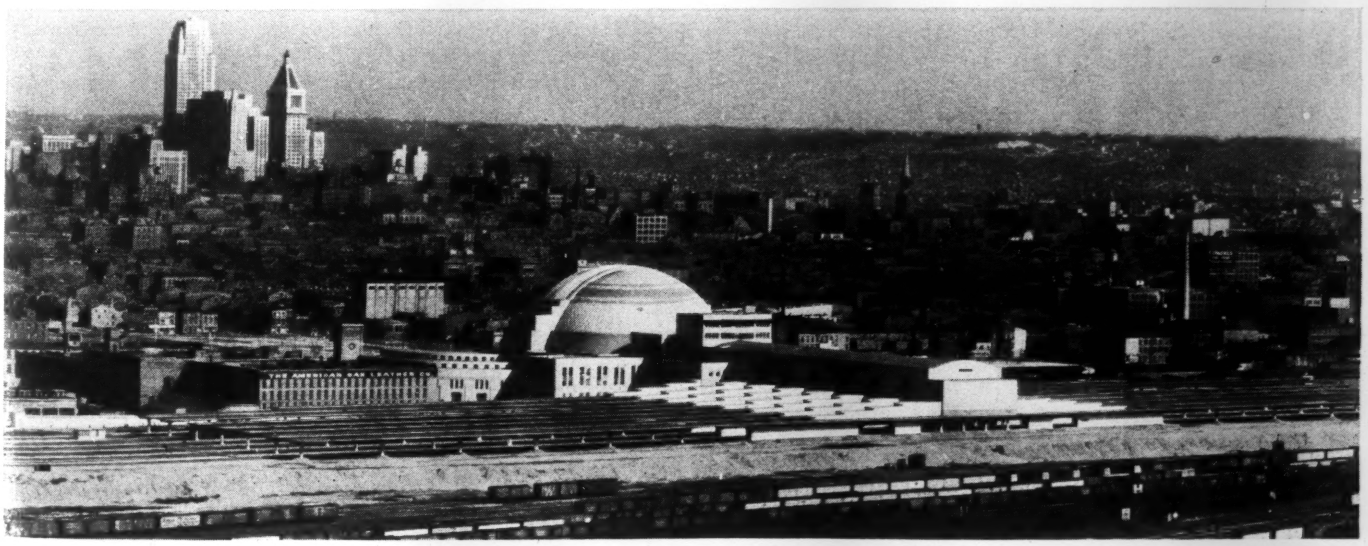
UNUSUAL are many of the features incorporated in the heating and ventilating of the new Cincinnati Union Terminal,[1] which was opened formally April 1. Before discussing them in detail it will be well to give a brief description of the system in general.

The train concourse, principal vestibules, and the various concessions, such as the theater, tea rooms, and the like, are heated by indirect systems. The ramped vestibules leading to the track platforms are served by recirculating fan units, while the baggage room and adjacent spaces are heated by suspended unit heaters. Remaining spaces, including the roof space over the main concourse, are taken care of by heating surfaces of various types, exposed or enclosed.

All ducts are continuous, run without interruption to and from the grilles. Changes in shape at curves are made in a radial direction only; where changes in two dimensions are required, separate change-shape pieces have been installed. Heavily-galvanized sheet iron is used for all duct equipment.

Steam Piped One Mile From Power House

Steam at 225-lb pressure is obtained from the power



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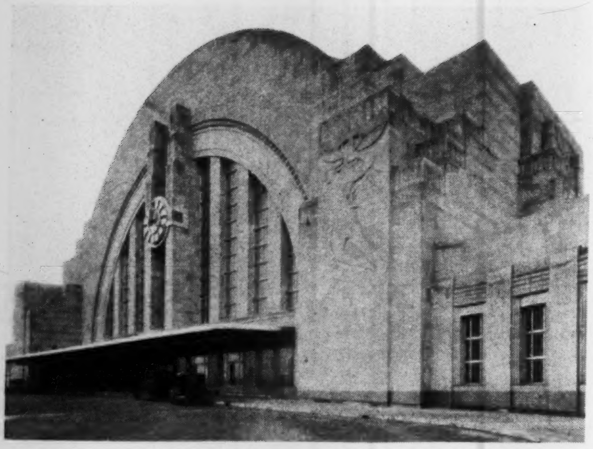
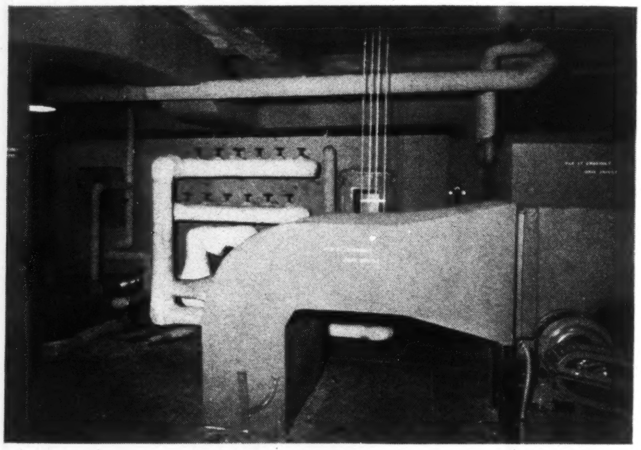
[1] Since 1908 had Cincinnati been toying with the idea of a passenger terminal to care for all the railroads entering the city; it was not until July, 1927, however, when an agreement was reached between the railroads and the newly-formed Cincinnati Railroad Terminal Development Company, that the project was finally initiated. Early in 1928, in accordance with a preliminary agreement made by the development company, the Cincinnati Union Terminal Company was chartered to carry out the work. Construction was begun in August, 1929; the entire terminal opened for operation April 1, 1933.

The project covers 287 acres. Of these, 45 are for the main passenger terminal, 69 for the engine terminal, and 16 for



Facade of the domed structure, virtually one enormous double window over six stories in height, with 3 ft between the inner and outer panes. Warm air circulating through the 3-ft space makes of it a great warm blanket. A general view of the terminal development from the other side is shown at the bottom of the preceding page



A complete air-conditioning unit is included in the theater ventilating system. The system may be operated either as a straight ventilating system or air may be recirculated through the dehumidifier. The spray water which floods the coils is recirculated by the pump unit shown here; the heavily-insulated piping is the brine supply for the cooling coils

house a little more than a mile north of the station. From the pressure-reducing equipment in the pump room a system of low-pressure (5-lb) heating piping and intermediate-pressure (40-lb) piping radiates to all heating surfaces and steam devices throughout the building. The hot-water heaters and kitchen equipment, which are in use the entire year, are connected to the intermediate-pressure system. Heating surfaces, such as radiators, tempering, and heating stacks are part of the low-pressure system.

All returns from low-pressure heating surfaces are collected and run to vacuum-return pumps. Intermediate-pressure returns are collected and run to a separate group of condensation pumps. A separate vacuum pump has been provided for the front portion of the station, condensation from which cannot conveniently be piped back to the main pumps. This pump discharges to the sewer through a cooling tank. Returns from the train concourse vestibule recirculating units are wasted into adjacent drain pipes.

Radiators in several of the rooms are thermostatically controlled. All tempering and heating stacks are automatically controlled; the control system is of the pneumatic type.

Twelve unit heaters with two-speed motors serve the baggage room, baggage platform, and adjoining areas. They direct the heated air from the coldest wall surface inwards.

Ventilation Provided by Several Systems

Ventilation is provided by several systems, grouped

---

mail and express facilities. The rest is used by the railroads which had to be changed from their former locations to allow for the construction of the new terminal. The site is in the lower Millcreek Valley, along the western boundary of Cincinnati's business and industrial basin. This valley cuts through the whole city, and by means of it four of the seven railroads had already gained ingress.

In addition to the six-million dollar station building, there are included in the terminal facilities an express building, a mail building, a new U. S. sub-post office building, an engine-house, a service building, and a power house.

The station building was designed by Fellheimer and Wagner, of New York. A domed structure with symmetrical wings on the north and south sides, it is the last word in this size of a purely passenger terminal. The dome, which rises 120 ft above the plaza, and whose arch has a span of 180 ft, forms the huge main concourse. From this enormous room, impressive both because of its sheer size and because of the beauty of its murals and other appointments, entrance may be had to the checking lobby and to the various appurtenances for the accommodation of passengers—such as a drug store, beauty parlor, haberdashery, gift shop—which are located about it on the main floor. The usual restaurant, lunch room, soda fountain, barber shop, and the like are included in the main-floor wings.

A unique feature is a small air-conditioned theater seating 118 people, where those who must wait for train connections may witness brief moving picture shows.

Directly behind the domed concourse, on either side of the high, square, checking lobby through which access is had to the train concourse and waiting room, extend the two symmetrical wings. Much of the mechanical equipment is housed here, on the mezzanine floor between the baggage and main floor levels. On this first office floor, directly above the main level, are the executive and administrative offices. This part of the building then rises, with big setbacks, for three more floors, the upper portions housing, for the most part, signalling, battery-charging, and other electrical equipment.

The domed portion is a gigantic quarter-sphere, so that its façade is essentially a huge vertical half-disk. Flanking it in the front, concealed in the "stepped" design on either side of the front window area, two small wings rise six floors above the main floor concessions. Many of the fan rooms, and the dehumidifier for the theater, are located there.

Stretching out from the rear of the main concourse and checking lobby is the train concourse, or waiting room. It is 80 ft wide and 500 ft long, and is on what is actually the second-floor level. In the rear of the station eight train platforms afford access to sixteen tracks. Ramps from the train concourse lead to these platforms. Baggage will be handled on the lower level of the wings.

The station affords accommodation for approximately 17,000 passengers daily, with 216 trains in and out. Street cars, taxicabs, and buses have separate lanes under the main concourse, while private automobiles gain access to the station at the plaza entrance.

so each serves some section of the building or some large concession. The north rear portion of the building is served by a group of three fans: air supply, toilet exhaust, and general exhaust (*i. e.,* exhaust other than from toilet rooms). A similar group of fans serves that portion of the south rear section not devoted to the lunch and dining rooms and their service requirements. The latter have a separate group of fans, consisting of an air-supply rig, hood exhauster, and general exhauster. The front portion of the building has its own general supply and general exhaust system. An individual system of supply and exhaust fans and connections for recirculation has been provided for the theater (where waiting passengers may view movie shows), which is the only part of the building that is air conditioned.

In all, 26 fan units are used, all of the high-speed backward-curved blade type. The largest, that for general supply in the north portion of the building, has a 51,000-cfm capacity. There is one of 42,500-cfm rating, and eight others have capacities of over 20,000 cfm. A fresh-air intake chamber, on the mezzanine floor, supplies the three large units—the north general, south general, and kitchen supply.

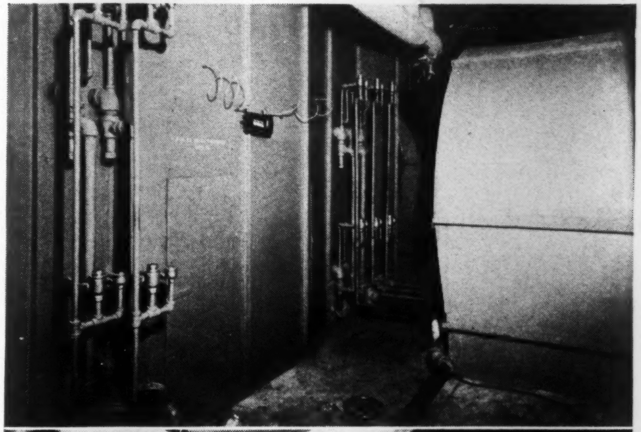
Each air supply unit, excepting the theater air-conditioning system, and each heating unit utilizing fresh air, is equipped with a pocket-type air filter. A fibrous textured mat, made up of multiple layers of porous cellulose material, and held in position between metal screens, forms the filtering medium.

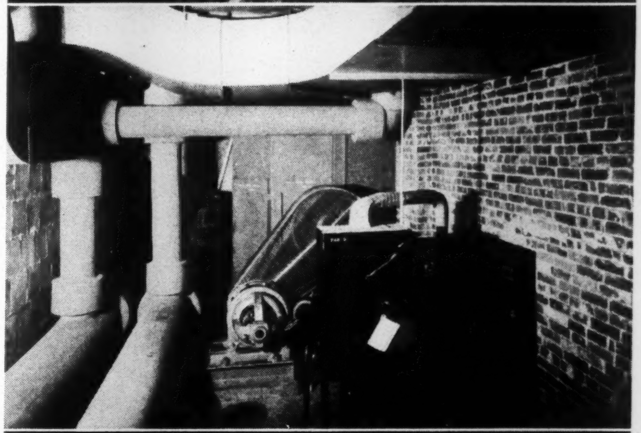
Warm Air Circulated in Great Double Window

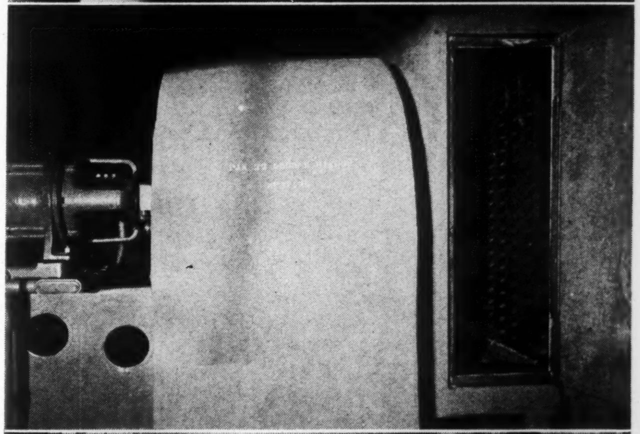
A somewhat unusual scheme has been devised to take care of the heat losses in the main concourse. The façade of this domed structure is practically one window expanse. A feature of the heating design is that no heat is supplied this 4,000,000-cu ft volume either by direct radiation or by an indirect duct system. Warm air from the train concourse and checking lobby to the rear is the positive source of heat; the heating provisions for the main concourse take care of heat losses only.

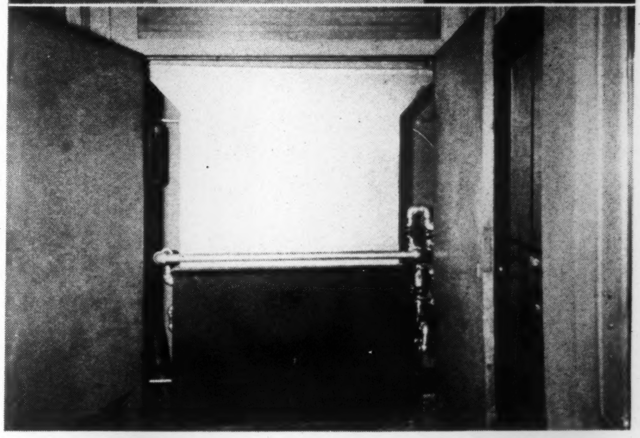
Of course, the enormous front window area presented a severe heat-loss problem. The expedient adopted was to make of this facade a great double window, with a 3-ft space between the outer and inner panes. The window is over six ordinary stories high; glass floors have been installed even with the six floor levels on either side. As a result, there are six passageways, 3 ft wide and 11 ft high, running the entire length of the front window. Through these passageways hot air is blasted, so that the window forms, in reality, a great warm blanket effectively shielding the entire main concourse front.

Two identical recirculating units, each of 8,000-cfm capacity, in a fan room on the fourth floor to the north of the main concourse, blow hot air through and exhaust









Top—Fresh air, at room temperature, is supplied to the train concourse from two fan rooms. A double set of tempering heaters is used to provide the proper temperature

Next—Ventilation demands in the north rear portion of the building are met by a single fan of 51,000 cfm capacity. This is the largest fan in the group of twenty-six

Next—A warm-air blanket, passed between the great double window in the front facade, is maintained by two recirculating units, each of 8,000-cfm capacity. Part of the heaters may be seen through the open duct door in the illustration

Bottom—Cold-air blasts and drafts from the ramped vestibules leading to the train sheds are eliminated from the main concourse by the use of recirculating heater units which are located behind wall doors. The heater units maintain a warm-air blanket at the head of the ramp, just inside the entrance doors

it from these passageways. Wound-rotor, 5-hp motors drive these fans through short-belt drives. The 60-in. heating stacks for the units contain 880 sq ft.

From the fan outlets two duct risers (interconnected by means of dampers at their base) extend side by side vertically to the top of the building, whence they run forward to the front and continue downward, to be tapped off for supply to individual passageways along one side of the double window. Their cross-sections, of course, diminish after successive taps. In a similar manner ducts are led up along the opposite side of the double window, again crossing over and extending down to the fan units. Thus a closed, recirculating system is established. These systems are cross-connected by dampers, so that in mild weather or in the event of breakdown one fan can circulate warm air through all the passages.

Fourteen Units Care for Roof Losses

Roof losses in the main concourse are taken care of by fin-wound, copper-tube heaters. In the trussed roof space on the fourth floor, fourteen such units are spaced equally along the great semi-circle formed by the domed shape of the building. The heating elements are mounted horizontally on angle-iron framework. Duct-work has been built up around these elements, extending 8 ft above and 2½ ft below, to produce a chimney effect which causes the heated air to rise forcibly against the roof.

Heating and Ventilating the Concourse

Fresh air at room temperature is supplied to the long waiting room, or train concourse, from two practically identical fan rooms located on the second office floor—one on each side of the building, in the wings. The fans—rated at 25,000 cfm against a static pressure of 1½ in.—are driven through multiple V-belt drives by 10-hp motors of the same type as those used for the double window fans. In each unit, between two sets of tempering stacks, is a group of the filters already described.

Connected to these fans two parallel, circular-section ducts run the entire length of the train concourse, just above the ceiling and along its center axis. These ducts feed six grilled openings, outlets which are entirely concealed by large, rectangular, diffusing lighting fixtures.

In addition to the system discharging through these ceiling openings, two 25,000-cfm, double-width fan units, located on the third floor level, discharge heated air through ducts which, eight on either side, lead to the vestibules that in turn give access to the train platforms below. The normal function of these units is that of recirculation. The fan inlets are connected to exhaust openings midway between the vestibule doors. However, a louver damper arrangement in the heating stack enclosures is such that instead of directing the air through the outlet grilles, they may by-pass it around the heating stacks directly to the air discharge duct leading out through the roof. Thus, in mild weather, this system may, with proper louver settings, operate as exhaust only.

Condensation From Vestibule Units Cooled

Each of the sixteen vestibules leading from the train concourse to the track platform is provided, as already indicated, with a recirculating heating unit similar to a school-room ventilator, but arranged for recirculation only. These units have furniture steel cabinets, with recirculating inlet grilles in the lower front panels and with outlet duct connection collars on the top. The cabinets inclose a condensation cooling coil, centrifugal fans and driving motor, heating element, and by-pass damper. The heating element, which is of the fin-wound, copper-tube type, is capable of raising 50-F inlet air to 128 F, with 2-lb steam pressure; the fans can deliver 1,500 cfm through the unit and the short duct connection at the outlet. To reduce revaporization in the headers to which they discharge, the returns from the heating coils are passed through a second fin-wound copper-tube heating element located in the inlet of each unit to cool the trap discharge of the main heating surface to 100 F with 50-F inlet air.

Brine-Type Dehumidifier for Theater

The theater dehumidifier is located in a fan room two floors above the theater. Duct and louver arrangement at the exhaust fan is such that the system may be operated as a straight ventilating system with supply and exhaust or air may be recirculated through the dehumidifier.

The dehumidifier is of sufficient capacity to handle 4,800 cfm, which the air supply fan will draw through it if no return air is utilized. Its cooling capacity is sufficient to maintain in the theater a dry-bulb temperature of 80 F and 55 per cent relative humidity when the outside conditions do not exceed 95-F dry bulb and 78-F wet bulb. The dehumidifier is equipped with brine coils in the air stream, flooded by the spray nozzles. The brine is obtained from a central plant which takes care of the kitchen refrigerators, drinking water and the like.

Oil Refining Process and Piping Explained by World's Fair Model

A MODEL oil refinery,[1] complete with glass-tube piping through which liquids flow realistically and miniature pumps which appear to be forcing the liquids through the pipe lines, is a feature of the exhibit of the American Petroleum Industries in the Hall of Science at A Century of Progress, Chicago. Piping engineers unfamiliar with the oil-refining process will find this model extremely informative; those conversant with it will be interested in the painstaking care with which the model has been constructed, down to model valves in the lines.

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[1] This exhibit, as well as an exhibit on petroleum production and geology, was constructed under the auspices of a committee representing the American Petroleum Industries, approximately 25 leading oil companies contributing the necessary funds. Detailed work of design and construction was performed by officials and engineers of the Pure Oil Company and the Standard Oil Company. To Wm. B. Plummer of the latter are we indebted for the illustration.

MODEL OIL REFINERY
AMERICAN PETROLEUM INDUSTRIES

Model oil refinery which demonstrates the process and shows the part piping plays

The model occupies a space approximately 10′ x 40′ exclusive of the explanatory signs surrounding the edge. It is constructed almost entirely of glass except for the bases and ends of various units which are of cast aluminum. All of the important operations of petroleum and refining are included. It starts in with the basic operation of fractional distillation whereby the crude oil is separated into the five principal raw products: gasoline, kerosene, gas oil, lubricating stock, and heavy fuel oil or asphalt. The refining of each of these products is then shown in successive units including a continuous treating plant for gasoline, an agitator for the chemical treating of kerosene, a cracking unit wherein gas oil is converted into cracked gasoline, a lubricating oil plant which includes an agitator for chemical treatment and chiller and filter press for removal of wax and a percolator for final treatment with clay. A coking still and an asphalt still are also shown for the conversion of the heavy fuel oil or residue from the crude oil into final products. The unit is constructed to approximately a 7-per cent scale with respect to modern refinery apparatus.

At the conclusion of the Fair, all of the petroleum exhibits will find a permanent home in the Rosenwald Museum of Science and Industry, in Chicago.

Large Refrigeration Piping Job

THE writer was recently involved in a large refrigeration piping job for cold-storage rooms calling for about ten miles of 2-in. piping. Perhaps other engineers will be interested in the following notes on this job.

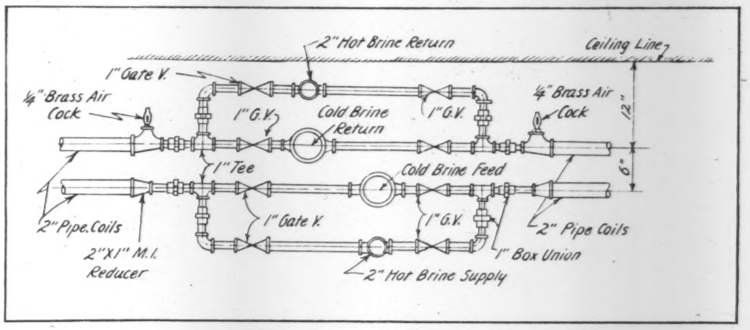
The piping was assembled in coils having an average length of 3000 ft served by an expansion valve. The refrigerating load on a typical coil results in a gas speed of approximately 2600 fpm which gives very good results. Stop valves are installed on both sides of each expansion valve and a built-in bypass around the expansion valve is provided so that repairs to the expansion valve can be made without disturbing the operation of the coils.

The pipe coils are made up of 40-ft lengths of 2-in. piping which were torch-welded on the job. Bent-pipe return-bends at 6-in. centers are used. Bearing stresses on the bolts in the ceiling of the room from which the coils are hung were figured on the basis that each foot of 2-in. piping, including the hangers and the ice formation which might occur, weighs 11¼ lb. The distance between the bolts in the length of the coils does not exceed 9 ft in any case and across the coils 4 ft 6 in., thereby insuring panels of pipe between the bolts which will not sag.

Wall coils are also used on this job. These are 12 pipes high, supported by 2½ x 2½ x ⅜ in. steel angles secured with a cast-iron floor plate and a ½-in. expansion bolt in the ceiling. Pipe hooks made of 5/16 in. x 2½ in. flat iron are riveted to this angle; while a 3/16 in. x 2 in. flat iron pipe hook would carry the load, it was deemed advisable to use the heavier material.

Due regard was given the arrangement of the headers to allow for creeping without joint injury. The suction mains were made amply large, because it is to be remembered that any reduction in suction pressure at the machine from the suction pressure existing in the coils means decreased machine capacity and consequent increase in power bills—a constant loss which is unnecessary.—*Robert S. Wheaton.*

Hook-up for brine coils. Cold brine feed and return lines taper in size from 4 to 2 in.



SLOW AND cumbersome is the solution of stresses in pipe bends due to their expansion . . . . . With a number of single-plane pipe bends this is simplified, however, by making use of the relationships outlined in the introduction of this article . . . . . The necessary coefficients have been determined and are shown in the charts, enabling the

Graphic Solution of Some Common Pipe Bends

By Samuel Kameros[*]

DETERMINATION of stresses in pipe bends due to their expansion is at best a slow process entailing a great deal of arithmetic and ending in the solution of simultaneous equations having cumbersome coefficients. However, for certain single-plane pipe bends which have wide application in high-pressure steam piping in industry, power plants, oil refineries, etc., the solution of these stresses is greatly simplified since the following relations are established:

1. The restraining force and restraining moment are directly proportional to some function of the ratio of the elements ($r = b/a$) of the bend.
2. These reactions are also directly proportional to the coefficient of expansion of the pipe, the moment of inertia and the modulus of elasticity.
3. The restraining force is inversely proportional to the square of the denominator of the ratio of the elements.
4. The restraining moment is inversely proportional to the denominator of the ratio of the elements.

These relations may be written as follows:

$$F = f\,(r)\,\frac{c\,EI}{a^2}\,\dots\dots\dots\dots\dots\dots\,(a)$$

$$M = f'\,(r)\,\frac{c\,EI}{a}\,\dots\dots\dots\dots\dots\dots\,(b)$$

In these equations the coefficient of expansion c, the modulus of elasticity E, and the moment of inertia I, are always known quantities. The length a, is known or assumed. The problem from this point becomes twofold. Either the ratio r is known or the desired stress is known. In the former, only the numerical value of the function of the ratios need be known to make the problem one of substitution in a simple equation; in the latter the procedure is the reverse—namely, for what value of r will a certain maximum stress be obtained?

Thus all that is required is the coefficient expressing a function of the ratio of the elements. These coefficients have been determined for five common types of pipe bends and are plotted for convenient use in Figs. 1, 2, 3, 4 and 5. These curves relate solely to pipes totally restrained or anchored at both ends with the weight of the pipe itself relieved by suitable hangers. The method of deriving these curves can be adapted for partially restrained ends and for hinged ends, two conditions which, however, are rarely met with in power plant or refinery design.

I. Right-Angle Bend

If the reactions in a right-angle bend, such as is shown in Fig. 1, were determined by any method the following would be the result:

$$F_X = \frac{3\,dx\,EI\,(a^2 + 4\,ab) + 9\,dy\,EI\,b^2}{ab^3\,(a + b)}\,\dots\dots\dots\,(c)$$

$$F_Y = \frac{9\,dx\,EI\,a^2 + 3\,dy\,EI\,(4\,ab + b^2)}{a^3b\,(a + b)}\,\dots\dots\dots\,(d)$$

$$M_o = -\left[\frac{3\,dx\,EI\,a^2 + 3\,dy\,EI\,(2\,ab + b^2)}{a^2b\,(a + b)}\right]\dots\dots\dots\,(e)$$

Substitute in Equations c, d and e the following equivalents:

$$b = r\,a$$
$$dy = r\,dx = r\,a\,e$$

Symbols Used in This Article

E: modulus of elasticity, lb per sq in.
I: moment of inertia, quartic inches (inches^4)
w: section modulus, cubic inches
c: coefficient of expansion, in. per in.
S: stress, lb per sq in.
F_X: horizontal component of restraining force, lb
F_Y: vertical component of restraining force, lb
M_o: restraining moment at left hand end of pipe bend, in.-lb
a: horizontal element of pipe length, inches
b: vertical element of pipe length, inches
r: ratio of elements $= b/a$
dx: horizontal expansion, inches
dy: vertical expansion, inches

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[*] Mechanical Engineer's Department, The New York Edison Company, New York City.

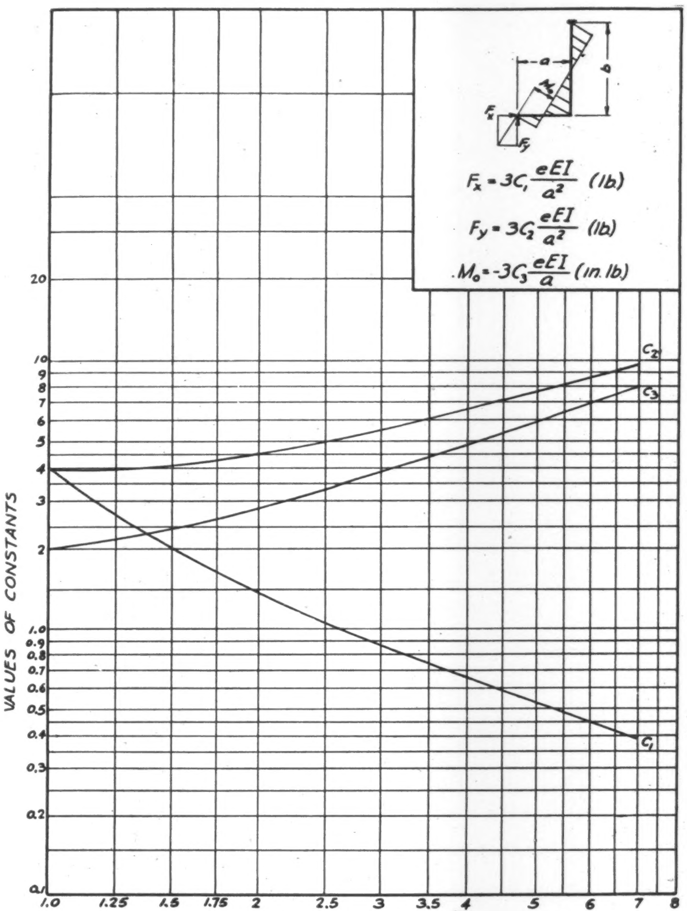


Fig. 1—Right-angle bend—values of Constants C for various ratios of b/a

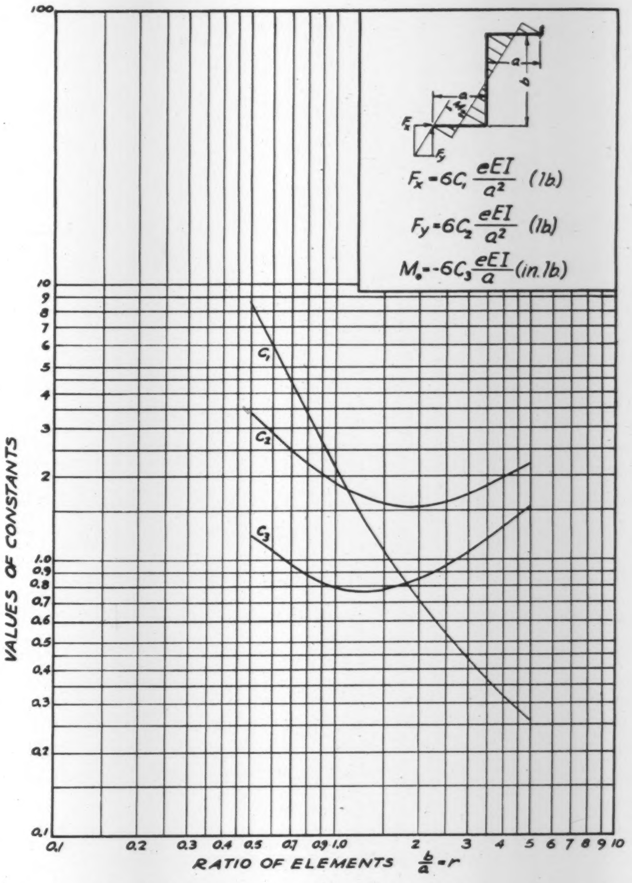


Fig. 3—Zee bend—values of Constants C for various ratios of b/a

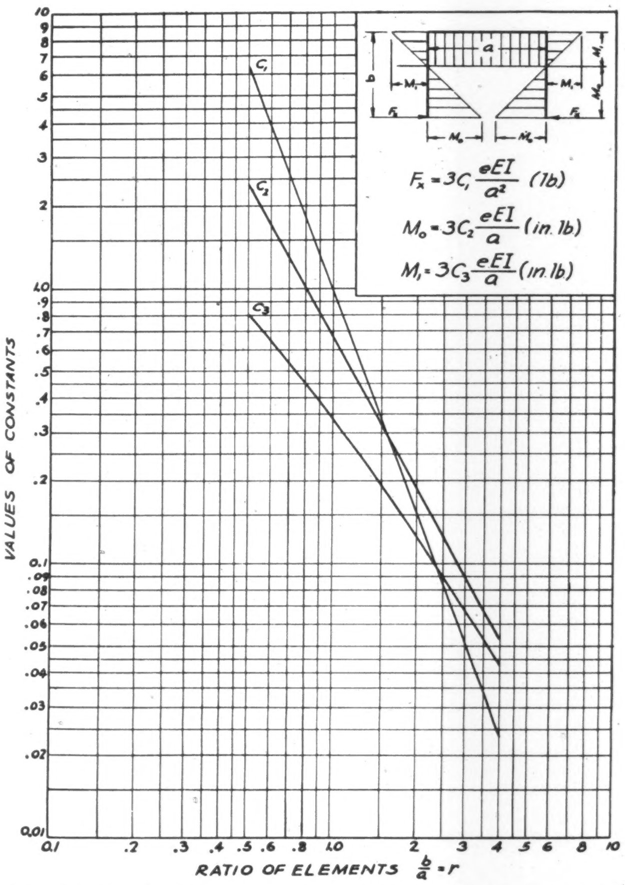


Fig. 2—Simple U-bend—values of Constants C for various ratios of b/a

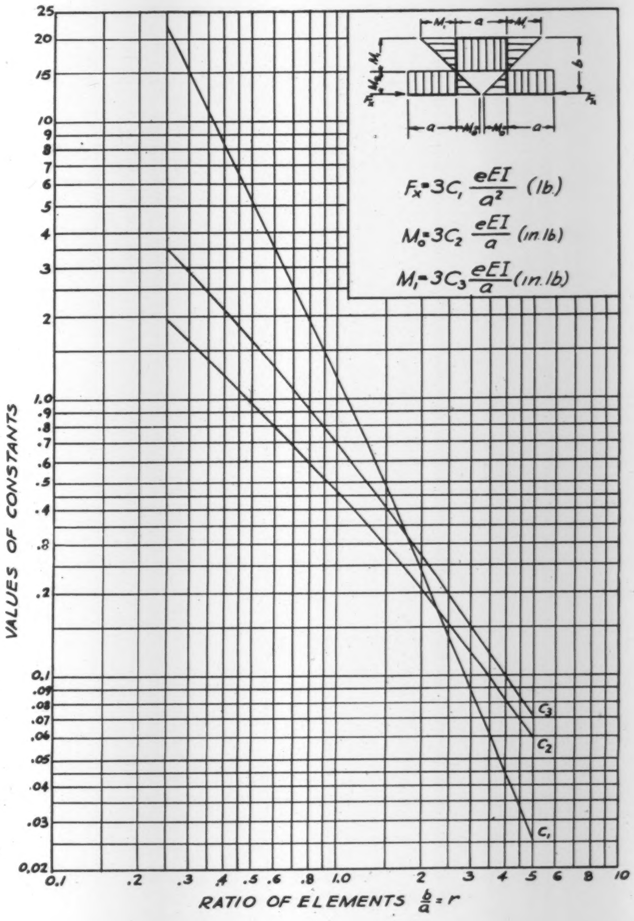


Fig. 4—Expansion U-bend (equilateral type)—values of Constants C for various ratios of b/a

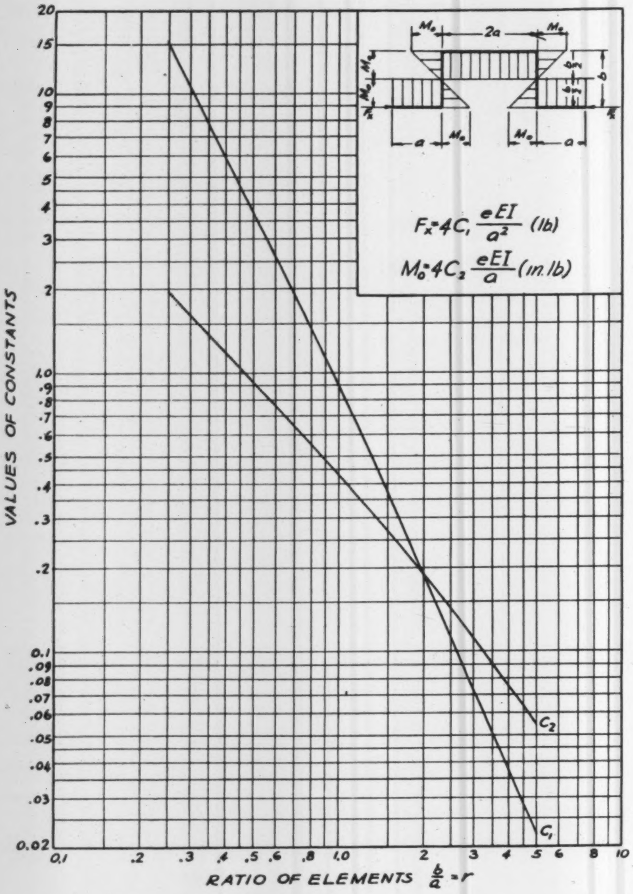


Fig. 5—Expansion U-bend (optimum type)—values of Constants *C* for various ratios of *b/a*

The following simplified expressions are then obtained:

$$F_X = \frac{3\,e\,EI}{a^2} \times \frac{3\,r^3 + 4\,r + 1}{r^3\,(r+1)} = 3\,C_1\,\frac{e\,EI}{a^2} \quad \ldots\ldots (1)$$

$$F_Y = \frac{3\,e\,EI}{a^2} \times \frac{r^3 + 4\,r^2 + 3}{r\,(r+1)} = 3\,C_2\,\frac{e\,EI}{a^2} \quad \ldots\ldots (2)$$

$$M_o = -\frac{3\,e\,EI}{a} \times \frac{r^3 + 2\,r^2 + 1}{r\,(r+1)} = -3\,C_3\,\frac{e\,EI}{a} \,\ldots (3)$$

The expressions involving functions of the Ratio *r* are plotted in Fig. 1.

II. Simple U-Bend

The equations for a simple U-bend, Fig. 2, are

$$F_X = \frac{3\,e\,EI}{a^2} \times \frac{2\,r + 1}{r^3\,(r+2)} = 3\,C_1\,\frac{e\,EI}{a^2} \quad \ldots\ldots\ldots\ldots (4)$$

$$M_o = \frac{3\,e\,EI}{a} \times \frac{r + 1}{r^2\,(r+2)} = 3\,C_2\,\frac{e\,EI}{a} \quad \ldots\ldots\ldots\ldots (5)$$

The distance of the neutral axis from the anchors is

$$n = \frac{M_o}{F_X} = \frac{a\,r\,(r+1)}{2\,r+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (f)$$

The distance of the horizontal member of the bend from the neutral axis then is

$$n^1 = b - \frac{a\,r\,(r+1)}{2\,r+1} = a\,r - \frac{a\,r\,(r+1)}{2\,r+1} = \frac{a\,r^2}{2\,r+1}$$

Hence the bending moment in the horizontal member is

$$M_1 = F_X\,n^1 = \frac{3\,e\,EI}{a\,r\,(r+2)} = 3\,C_3\,\frac{e\,EI}{a} \quad \ldots\ldots\ldots\ldots (6)$$

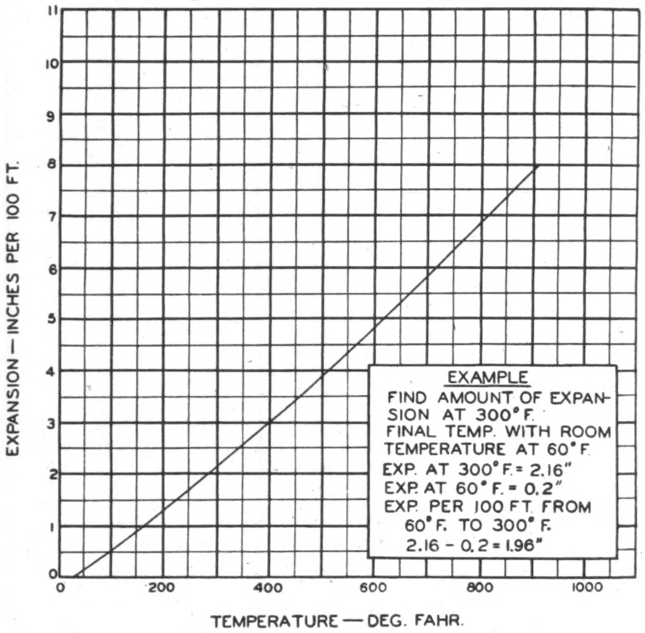
The equations for the reactions in the other types of bends are derived in the same manner and only the coefficients involving the function of the ratio of the elements are given.

III. Zee Bend

(*See Figure* 3)

$$C_1 = \frac{3\,r^2 + 8}{r^2\,(2\,r+3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$C_2 = \frac{r^3 + 6\,r^2 + 12}{2\,r\,(2\,r+3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$



EXAMPLE

FIND AMOUNT OF EXPANSION AT 300° F.
FINAL TEMP. WITH ROOM TEMPERATURE AT 60° F.
EXP. AT 300° F. = 2.16"
EXP. AT 60° F. = 0.2"
EXP. PER 100 FT. FROM 60° F. TO 300° F.
2.16 - 0.2 = 1.96"

Fig. 6—Linear expansion of steel pipe

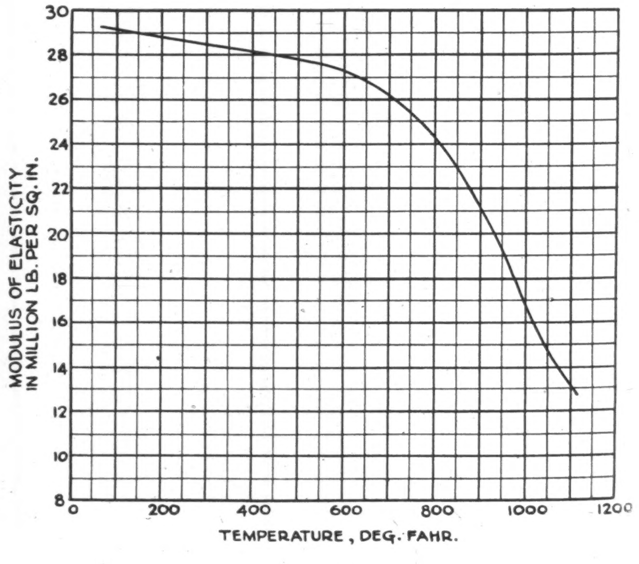


Fig. 7—Modulus of elasticity at different temperatures

$$C_3 = \frac{r^3 + 3\,r^2 + 4}{2\,r\,(2\,r + 3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

IV. Expansion U-Bend—Equilateral Type

(*See Figure* 4)

$$C_1 = \frac{3\,(2\,r + 3)}{r^2\,(r^2 + 6\,r + 6)} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

$$C_2 = \frac{3\,(r + 1)}{r\,(r^2 + 6\,r + 6)} \quad \ldots\ldots\ldots\ldots\ldots (11)$$

$$C_3 = \frac{3\,(r + 2)}{r\,(r^2 + 6\,r + 6)} \quad \ldots\ldots\ldots\ldots\ldots (12)$$

V. Expansion U-Bend—Optimum Type

(*See Figure* 5)

$$C_1 = \frac{6}{r^2\,(r + 6)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

$$C_2 = \frac{3}{r\,(r + 6)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Examples of Use of Curves

To illustrate the use of the curves two typical examples are given:

Example 1. It is required to find the reaction force, bending moments and maximum stress due to expansion alone in a simple U-bend (Fig. 2) under the following conditions.

Pipe size, 12 in., 600 lb, seamless-steel tubing
Steam temperature, 850 F
Room temperature, 60 F
$a = 200$ in.
$b = 200$ in.
$e = 7.20$ in. per 100 ft $= 0.006$ in per in. (Fig. 6)
$E = 23 \times 10^6$ lb per sq in. (Fig. 7)
$I = 438.7$ in.^{4} (Table 1)
$w = 60.03$ in.^{3} (Table 2)

Proceed as follows:

$$\frac{b}{a} = \frac{200}{200} = 1$$

From curves in Fig. 2:

$$C_1 = 1.00$$
$$C_2 = 0.67$$
$$C_3 = 0.33$$

Then

$$F_x = \frac{3 \times 1.00 \times 0.006 \times 23 \times 10^6 \times 438.7}{40000} = 4540 \text{ lb}$$

$$M_o = \frac{3 \times 0.67 \times 0.006 \times 23 \times 10^6 \times 438.7}{200} = 608{,}400 \text{ in.-lb}$$

$$M_1 = \frac{3 \times 0.33 \times 0.006 \times 23 \times 10^6 \times 438.7}{200} = 304{,}200 \text{ in.-lb}$$

Maximum stress, therefore, occurs at the anchors and is numerically equal to:

$$S = \frac{M_o}{w} = \frac{608{,}400}{60.03} = 10{,}130 \text{ lb per sq in.}$$

Example 2. It is decided that this stress is too high and that the bend must be redesigned to give not over 7,000 lb per sq in. stress due to expansion alone with the same distance between the anchors.

Proceed as follows:

$$M_o = S\,w = 7{,}000 \times 60.03 = 420{,}200 \text{ in.-lb}$$

$$M_o = 3\,C_2\,\frac{e\,EI}{a}$$

$$420{,}200 = \frac{3\,C_2 \times 0.006 \times 23 \times 10^6 \times 438.7}{200}$$

$$C_2 \doteq 0.46$$

From Fig. 2, $C_2 = 0.46$ when $r = 1.3$.

Hence by making $b = 1.3\,a = 1.3 \times 200 = 260$ in., the desired maximum stress is attained.

Moment Diagram

In cases involving a right-angle bend and a zee bend it is necessary to construct moment diagrams, such as are shown in Figs. 1 and 3, respectively, to determine the point of maximum stress. This is accomplished by

Table 1—Moment of inertia for standard steel and W. I. pipe sizes

NOMINAL PIPE SIZE INCHES	MOMENT OF INERTA, INCHES^4					
	250-LB	400-LB LAP-WELDED	400-LB SEAMLESS	600-LB	900-LB	1350-LB
½	0.017	....	0.017	0.020	0.020	0.020
¾	0.037	....	0.037	0.045	0.045	0.049
1	0.087	....	0.087	0.106	0.106	0.118
1¼	0.195	....	0.195	0.242	0.242	0.284
1½	0.310	....	0.310	0.391	0.391	0.482
2	0.666	0.868	0.710	0.776	0.955	1.102
2½	1.530	1.924	1.530	1.611	1.924	2.353
3	3.017	3.894	3.017	3.294	4.014	4.81
3½	4.788	6.280	4.788	5.712	6.656	8.24
4	7.233	9.610	7.233	8.332	10.42	12.75
5	15.16	20.67	15.16	19.65	23.30	30.0
6	28.14	40.49	28.84	36.87	45.40	57.3
8	72.49	105.7	76.80	100.2	126.4	162
10	160.7	212.0	172.5	223.0	295.9	384
12	279.3	361.5	361.5	438.7	578.7	742
14 O.D.	401.1	588.6	483.8	614.0	825.0	1082
16 O.D.	690.3	971.3	773.3	1047	1365	1815
18 O.D.	1053	1515	1231	1623	2180	2908
20 O.D.	1624	2409	1787	2483	3316	4378
24 O.D.	3137	4524	3705	4917	6740	9006

Notes: $I = \frac{\pi}{64}(D^4 - d^4)$ in.^{4} Moments of inertia correspond to dimensions of pipe given in *A. S. T. M. Specification A106-29.*

Table 2—Section Moduli—Based on minimum outside diameter and minimum wall thickness

NOMINAL PIPE SIZE INCHES	SECTION MODULI, INCHES^3			
	600-LB SEAMLESS TUBING	400-LB LAP-WELDED PIPE	400-LB SEAMLESS TUBING	250-LB LAP-WELDED PIPE
½	0.039	....	0.0341	*
¾	0.073	....	0.0600	....
1	0.140	....	0.114	....
1¼	0.255	....	0.202	....
1½	0.361	....	0.284	....
2	0.576	0.647	0.525	0.492
2½	0.987	1.189	0.936	0.935
3	1.654	1.970	1.510	1.511
3½	2.515	2.767	2.096	2.093
4	3.246	3.762	2.800	2.808
5	6.195	6.526	4.756	4.749
6	9.740	10.72	7.583	7.394
8	20.31	21.43	15.49	14.60
10	36.22	34.33	27.90	25.93
12	60.03	49.27	49.24	37.96
14 O.D.	76.43	73.24	59.94	49.64
16 O.D.	114.12	105.7	83.84	74.74
18 O.D.	157.1	146.3	118.7	101.4
20 O.D.	216.4	209.9	155.0	140.6
24 O.D.	356.8	327.6	267.5	226.2

*½" to 1½" 250-lb pipes are seamless.

finding the resultant reaction at the anchor and locating the neutral axis. Thus:

$$F_r = \sqrt{F_X^2 + F_Y^2}$$

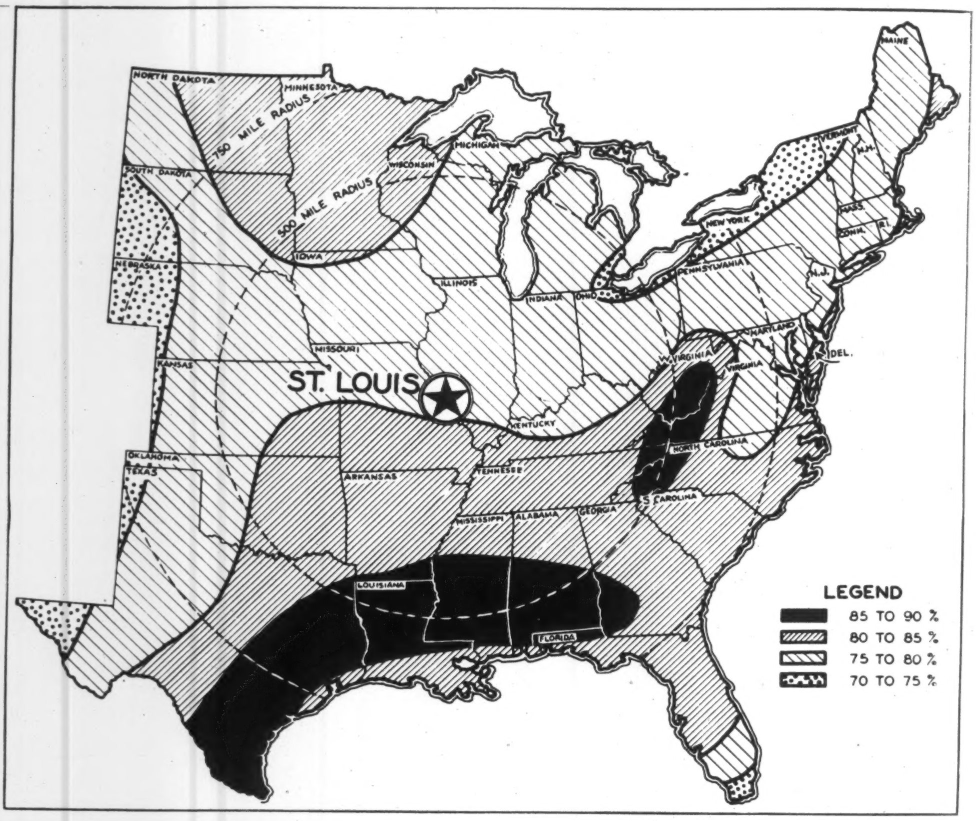
The neutral axis will be parallel to the line of action of the resultant reaction, and located at the distance from it of

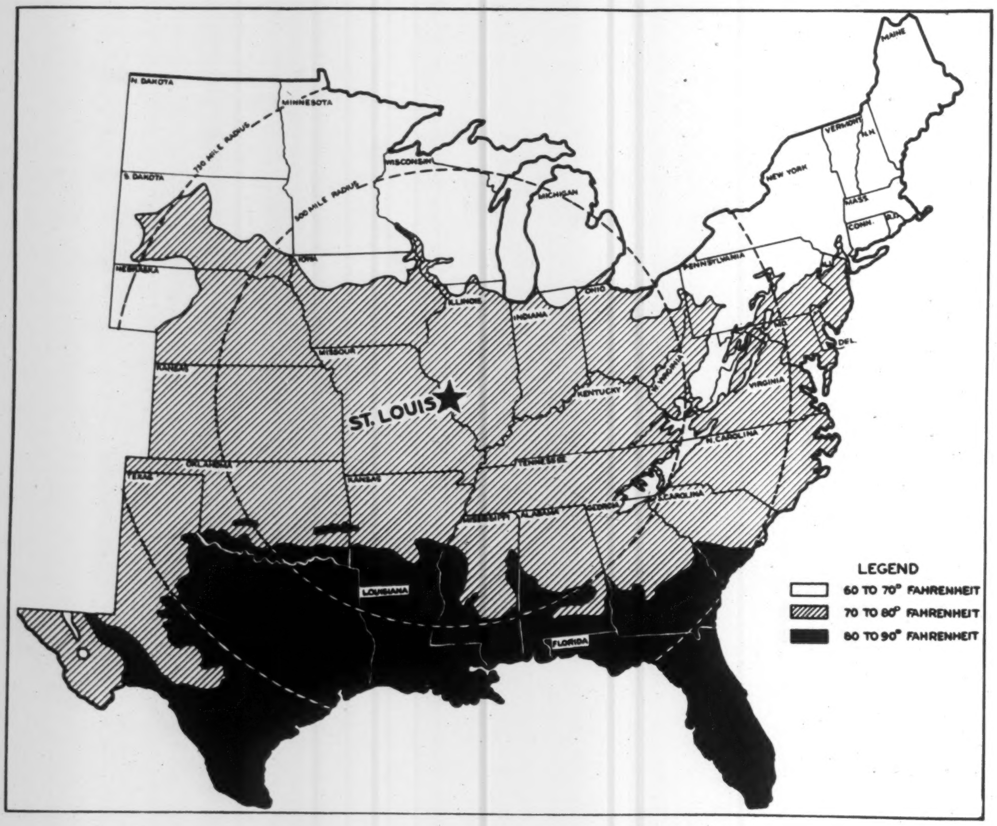
$$n = M_o \div F_r$$

The moment at any point in the pipe line is then equal to the perpendicular distance of that point from the neutral axis multiplied by the resultant reaction, or

$$M_P = F_r n_P$$

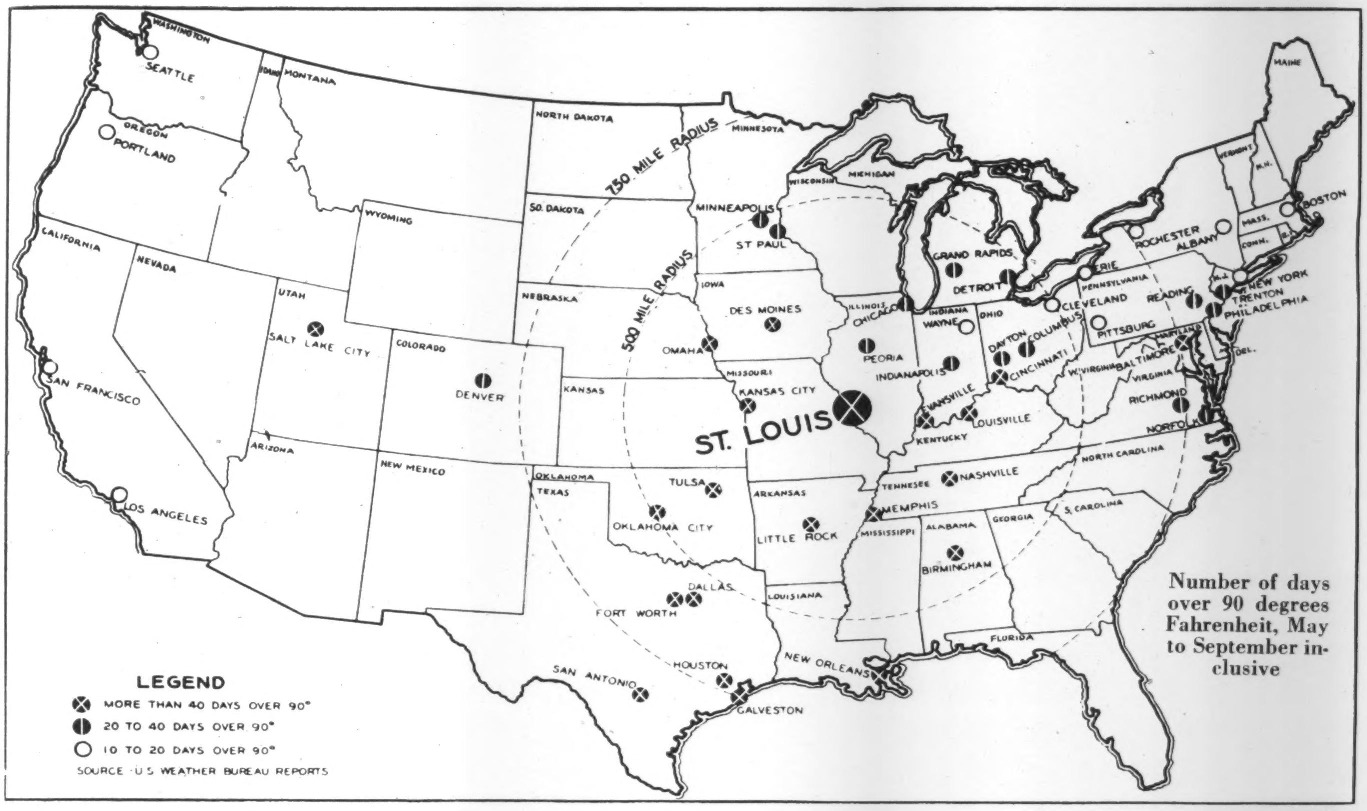
St. Louis Center of "Cooling Belt," Survey Indicates


ST. LOUIS
750 MILE RADIUS
500 MILE RADIUS
LEGEND
85 TO 90 %
80 TO 85 %
75 TO 80 %
70 TO 75 %


ST. LOUIS
750 MILE RADIUS
500 MILE RADIUS
LEGEND
60 TO 70° FAHRENHEIT
70 TO 80° FAHRENHEIT
80 TO 90° FAHRENHEIT

Above—Average relative humidity for a typical summer month. Based on 20-year records for July, 8:00 a. m. U. S. Weather Bureau. Left—Average summer temperature, based on 20-year records of U. S. Weather Bureau

To show that St. Louis is the center of the "cooling belt" is the purpose of the three maps reproduced here. These charts form an "air-conditioning survey" recently made by the Industrial Bureau of the Industrial Club of St. Louis; they were prepared by M. M. Drake, director of research of the Club, and thanks are due John Ring, Jr., manager of the Industrial Bureau, for permission to publish them.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SAN FRANCISCO
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NEVADA
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MONTANA
WYOMING
UTAH
SALT LAKE CITY
COLORADO
DENVER
ARIZONA
NEW MEXICO
NORTH DAKOTA
SO. DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
750 MILE RADIUS
500 MILE RADIUS
MINNESOTA
MINNEAPOLIS
ST PAUL
IOWA
DES MOINES
OMAHA
MISSOURI
KANSAS CITY
ST. LOUIS
TULSA
OKLAHOMA CITY
DALLAS
FORT WORTH
HOUSTON
SAN ANTONIO
GALVESTON
ARKANSAS
LITTLE ROCK
LOUISIANA
NEW ORLEANS
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MICHIGAN
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W. VIRGINIA
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RICHMOND
NORFOLK
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BALTIMORE
DEL.
PENNSYLVANIA
PITTSBURG
ERIE
READING
PHILADELPHIA
TRENTON
N.J.
NEW YORK
ROCHESTER
ALBANY
VERMONT
N.H.
MAINE
MASS.
BOSTON
CONN.
R.I.
LEGEND
⊗ MORE THAN 40 DAYS OVER 90°
◐ 20 TO 40 DAYS OVER 90°
○ 10 TO 20 DAYS OVER 90°
SOURCE U.S. WEATHER BUREAU REPORTS

Number of days over 90 degrees Fahrenheit, May to September inclusive

The survey was made to bring to the attention of the air-conditioning industry and air-conditioning engineers that St. Louis is centrally located to summer air-conditioning activities.

Plants Report Savings from Modernizing with Unit Heaters

MODERNIZATION of industrial-plant heating systems with unit heaters has been extensive and savings in heating costs from 20 to 50 per cent have been reported. These savings are usually the greatest where the proportion of overhead heat loss to other heat losses is the greatest. Add to this the economies possible through the use of automatic temperature control adaptable to this type of heating and it will be found that theory substantiates the savings that are being reported.

Installing Strainers on Unit Heaters

Speaking of unit heaters brings to mind a funny thing which has happened in plant heating in the last few years. For many years it has been the habit to install strainers at the return end of pipe coils to prevent scale and dirt from the coils injuring the trap or valve in the return connection. With unit heaters the same habit has continued, whereby strainers are usually installed at the return end of unit heaters. It would seem advisable to place the strainer in the supply connection to the unit heater where it will protect the relatively small and valuable tube area of this piece of apparatus as well as the trap or valve in the return connection.—*A. W. Moulder.**

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*Manager, Heating-Power and Industrial Piping Division, Grinnell Company, Providence, R. I., and Member of Board of Consulting and Contributing Editors.

Bulletin Tells How to Secure Economy in Mine Ventilation

THE greatest opportunities for effecting economies in mine ventilation lie, as a rule, in those parts of the mine where the air is forced to move with the greatest speed. This is usually in the aircourses leading from the airshaft, sometimes called the "high velocity zone."

With the hope of presenting evidence of the economy resulting from improvements in aircourses the investigation described in Bulletin No. 249 of the Engineering Experiment Station of the University of Illinois (Urbana, Ill.) was undertaken. The effects of cleaning, enlarging, and otherwise improving the aircourses in the high velocity zone at a large coal mine were studied.

The zones which were improved and studied in detail consist of a length of nominally straight entry, a T split with a regulator in one branch, and a square bend at the bottom of the intake shaft compartment. The improvements consisted in the clearing of the fallen debris and timbers from the aircourse, the replacement of the original regulator by one with an adjustable central discharge opening, and the enlargement of the shaft bottom outlet. Finally, a set of deflecting vanes was installed in the shaft bottom to aid in changing the course of the air from vertical to horizontal.

Results indicated that, where the mean cross-sectional area of aircourses in the high velocity zone of a mine can be increased considerably, say 50 per cent or more, and maintained at moderate expense without the excessive use of obstructing timbers, substantial savings in ventilation costs can be effected; and that the installation of a suitable set of vanes in a shaft bottom of the type investigated should result in net annual savings in excess of the original cost of installation.

RELIEF FOR sufferers from hay fever and pollen asthma—and an important application for air filtering—is indicated by the U. of I. studies reported here . . . At other institutions (notably Johns Hopkins) similar conclusions have been reached . . . Timely is the subject now, with the hay-fever season approaching.

Filtered Air Relieves Hay Fever

By William H. Welker, *Ph. D.*,
B. Z. Rappaport, *M. D.*,
and Tell Nelson, *M. D.* *

FILTRATION of air for the removal of symptom-producing substances in hay fever and pollen asthmatics and other environmental allergic disturbances is comparatively a new idea from the angle of the ventilating engineer. For three hay-fever seasons we have been studying the amount of relief that can be given to sufferers from hay fever and from pollen asthma by the filtration of the air furnished to the patients.

Results of Studies on Filtered Air for Hay Fever

1. Air filtration of a high degree of efficiency for the removal of pollen will relieve symptoms of hay fever.
2. Air filtration of a high degree of efficiency for the removal of pollen will relieve the symptoms of pollen asthma, but the time required for the relief of these symptoms is very much greater than that in the case of hay fever.
3. The removal of pollen from air by filtration is in no sense a cure for either hay fever or pollen asthma. It merely removes the irritating material and is effective only as long as the patient is not exposed to this irritating material. Personal efficiency of hay-fever patients can be increased by filtering the air in which they spend the nights because of the increased amount of restful sleep that can be secured.
4. Filters designed to be used in connection with hay fever or pollen asthma must be so constructed that there is no leakage whatever of unfiltered air around the filter forms or at the edges of the filter material.

From the results obtained in experiments with air filtration in connection with the drying apparatus used in the work on proteins in our laboratory, we believed that it would be possible to remove the greater portion of pollen by the filtration of the air through the proper type of filters.

The filtration of air for the removal of pollen presents a somewhat different problem than the filtration for the removal of the major portion of the dust. In ordinary filtration a small percentage of dust passing through the filters, or through leaks around the edges of the filters, is not an extremely serious matter. However, in filtering air for the removal of pollen, or other environmental allergic material, it is necessary to remove such material as completely as possible because highly-sensitized individuals will respond with symptoms to extremely minute amounts of such substances. Under such conditions the whole purpose of filtration would be defeated. The ragweed pollen grain has a diameter varying from 12 to 20 microns. With such minute particles it is necessary to have a very close mesh filter material if any appreciable velocity of air is to be maintained through the filter. In our experience with extremely small particles of soot in connection with the drying apparatus we obtain a greater efficiency by the use of a material with slightly coarser texture through which the air passes very slowly.

Leakage Around Filter a Problem

In the summer of 1930 we conducted the first experiments with an apparatus consisting of three air-filter units and a blower. The apparatus was constructed so that the air was passed through two of the filter units in parallel, and subsequently, all of the air passed through the third unit. Trouble was experienced because of leakage around the filter forms in the filter units and around the doors of the apparatus into which these units had been built. Therefore for the work of the summer of 1931[1] our experiments were conducted with two specially-constructed units consisting of a blower with filter forms holding cellulose filters in the intake portion of the machine. Trouble was again experienced with leakage around the filter forms. For the work in the summer of 1932, these machines were rebuilt so that the air passed through two sets of filters and the construction of the supports for the filter forms was improved so that there was very much less apparent leakage.

An eight-bed ward was operated with two of these machines each of which had a capacity of 800 cfm with a filter surface of 22.6 sq ft. During this season we also operated a four-bed ward with two machines in which the air was filtered through a single layer of filter material which in this case consisted of a heavy wool felt. Each of these machines had a capacity of 450 cfm with a filter area of 20 sq ft.

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*Of the Departments of Physiological Chemistry, Pathology and Medicine, respectively, College of Medicine of the University of Illinois, Chicago, Ill.

[1] The charts published here are based on the work during the 1931 season.

Determining the Efficiency of the Filters

The efficiency of the filters was studied by two methods. First by exposing vaselined slides in the incoming current of air and in the outgoing filtered air for definite periods of time, counting the pollen grains that adhered to the vaselined slide in a definite area (1.8 sq cm). The other method consisted of making counts of the pollen grains on the vaselined slides which had been exposed to the air outdoors and to the air in the room for definite periods of time. This is known as the settling count method.

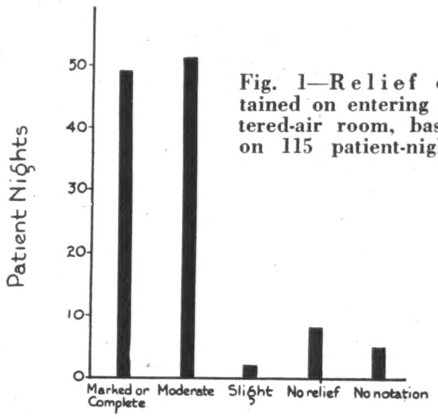


Fig. 1—Relief obtained on entering filtered-air room, based on 115 patient-nights

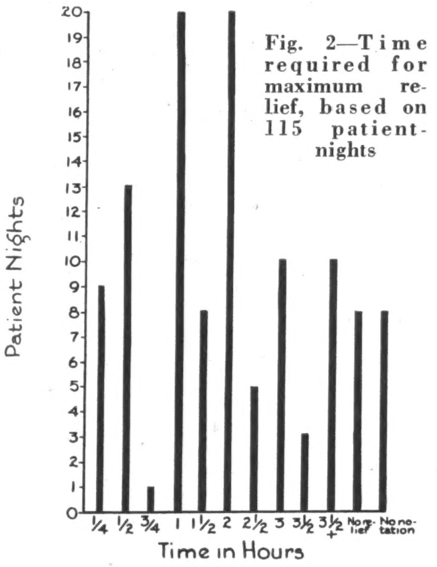


Fig. 2—Time required for maximum relief, based on 115 patient-nights

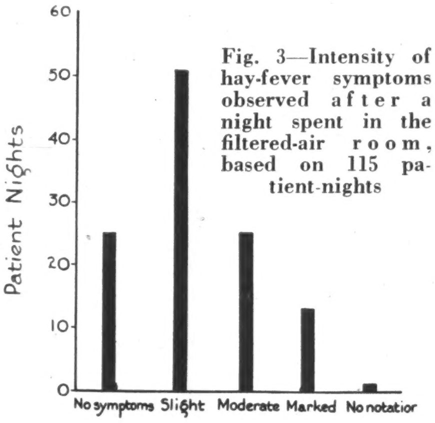


Fig. 3—Intensity of hay-fever symptoms observed after a night spent in the filtered-air room, based on 115 patient-nights

It must be apparent at once that neither of these two methods gives an accurate index of the number of pollen grains per unit volume of air. What is most urgently needed is a simple method for the determination of the number of pollen grains in a unit volume of air, and until such a method is available, it will be impossible to determine with any degree of accuracy the efficiency of any apparatus for the filtration of pollen from the air.

In the summer of 1931 our filters (on the basis of daily counts on vaselined slides exposed to moving air) showed an efficiency of 97 per cent. In the experiments conducted in 1932 in the one room on the basis of the settling counts, the filters showed an efficiency of 98.2 per cent and the filters in the smaller ward showed an efficiency of 95.98 per cent.

Clinical Observations on Hay-Fever Patients

Seventy-six patients with hay fever of the autumnal type and with positive skin tests to the ragweeds were observed for an aggregate of 299 nights during the pollen season of 1931 and 1932. These cases were observed for periods varying from three days to one week. They were admitted in the evening and remained in the filtered air for periods varying from 12 to 16 hours and were sent out during the day. The average time required for maximum relief of symptoms regardless of severity on entering the filtered air ward was 2.16 hours. On days when the pollen concentration of the air was high, a longer period of residence in filtered air was required for relief of symptoms.

In our series, 80.05 per cent of the patients had either great or complete relief of symptoms in three hours, or less, and 4.85 per cent had no relief.

Symptoms reappeared upon exposure to pollen-laden air in an average time of 1.7 hours over the entire period of 10 weeks, 5 weeks in each season. In each season, on those days when the pollen counts were high, symptoms would reappear within 5 minutes after exposure in a large percentage of our patients. Although the symptoms upon re-exposure were in many instances of severe degree, it was the consensus of opinion that personal efficiency was increased because of relief from pollen irritation during the night.

Clinical Observations on Pollen-Asthma Patients

Twenty-one pollen asthma patients were studied during August and September, 1931. The majority were observed for periods of 4 to 7 days during which they were confined strictly in filtered air. The asthma became less severe after twenty-four hours of confinement in all except two patients. These required 4 days before experiencing relief. The objective findings of wheezing cleared in only two patients, one after three days, the other after five days of observation. Four of the patients who were completely free of subjective symptoms, but who still had slight wheezing on examination, developed asthma one-half to one hour after leaving the ward.

Thirty-five untreated pollen-asthma patients were studied during the 1932 season. The subjective symptoms were relieved after a variable number of days of confinement depending upon the severity of the asthma. This period varied from one to seven days. The length of time that these individuals could remain outdoors after that depended on the pollen concentration outdoors and the sensitiveness of the individual. While some could tolerate an average of 4.9 hours outdoors, others could not be out for even one hour without suffering an attack of asthma. Four patients were admitted before the onset of asthma, who, during previous seasons, had regularly suffered attacks. Confinement in filtered air for 14½ to 15 hours daily did not prevent the onset of asthma in these individuals.

In addition to the influence of pollen concentration the effect of weather changes on pollen asthma was observed. On September 12, 1933, all seven patients who were in the filtered air, developed asthma simultaneously with the occurrence of a heavy rain, a marked drop in the barometric pressure, a sudden drop in temperature and a sharp rise in humidity. It is our belief that the atmospheric changes were important in inducing the attacks of asthma in these individuals, since the pollen count in the room and the rate of air change remained unaltered.

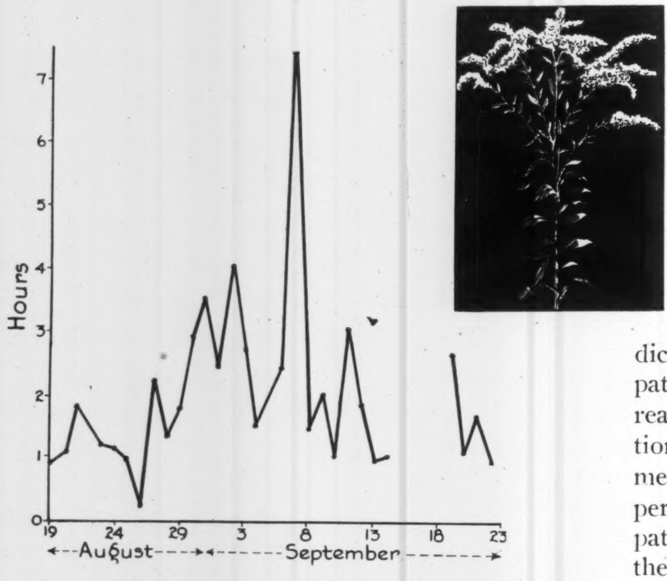


Fig. 4—Average time required for maximum relief from hay-fever symptoms on various days of the experiment

Filtered Air Gives Relief, Increases Efficiency of Hay-Fever Sufferers

The results of our experiments show that the symptoms of hay fever will disappear to the point where there is practically no discomfort, in 80 per cent of the patients studied, after they have been in filtered air for three hours or less. The filtration must have a high degree of efficiency for the removal of the pollen; otherwise, no such degree of success can be obtained with respect to the disappearance of hay fever symptoms. Filtration, efficient for ordinary dust of the atmosphere might not meet these requirements.

The disappearance of hay-fever symptoms is not indicative of any cure of hay fever. As soon as these patients are exposed to pollen-laden air the symptoms reappear. Unless the patient can spend the major portion of the day in the filtered air this method of treatment cannot be regarded as a satisfactory one. Our experiments show that the personal efficiency of hay-fever patients can be increased by filtering the air in which they spend the nights because of the increased amount of restful sleep that can be secured in this fashion.

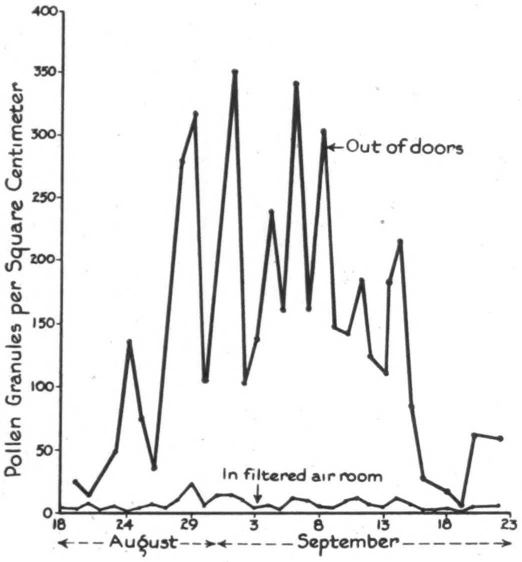


Fig. 5—Pollen counts per square centimeter taken in filtered-air room and out-of-doors

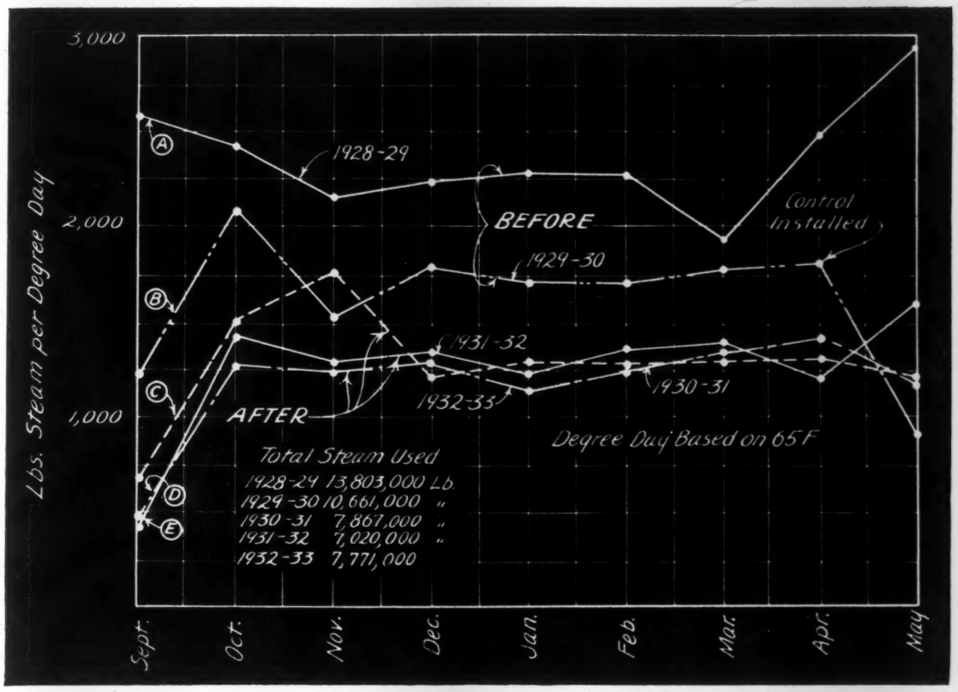
Pollen-Asthma Patients Respond More Slowly

Patients suffering from pollen asthma respond very much more slowly to the filtered-air treatment. The symptoms of pollen asthma are relieved in most patients by remaining in filtered air for periods varying from one to seven days. For these patients, no appreciable relief can be expected unless filtered air is supplied to them continuously.

Our experience in these experiments emphasizes the fact that the construction of ordinary filtration apparatus may not be applicable to filtration of air for the removal of pollen. The leaks around the supports for the filter forms and around the edges of the filters are usually too great to give any degree of practical efficiency for pollen removal. It is our belief that the most efficient removal of pollen can be obtained by using filters that do not have excessive air resistance and of such large area that the air velocity is very low.

Control Reduces Steam Consumption 22 Per Cent

By W. H. Meloan*



Pounds of steam per degree day for heating Consumers building, before and after automatic control system was installed. The results secured by George E. Lehner, the engineer, indicate that savings from the right control equipment can be added to the savings from careful operation

"IF we bought all the devices for saving coal that are offered to us, we would have to use a clam-shell bucket to scoop the coal out of the basement," says a boiler owner as though the thought were original and the crack were new. Once it was funny, but it is about time to nominate the thought for the hall of oblivion, for the reasoning behind it is totally fallacious.

While it is true that wild claims of economies are often made, and will continue to be made, the practice of adding up the economies of different types of fuel savers (always for comedy purposes) is usually unfair because the alleged economies of *duplicating* equipment are added. If oil firing costs less than gas firing, and stoker firing costs less than oil firing, any child can see that you can't fire a boiler by both and realize an economy equal to the sum of the claims. Yet that is the reasoning the wags use—fogging it, of course, with complications.

No engineer should let this sort of reasoning eclipse the fact that one saving *can* be super-imposed on another, providing they are not obtained by duplicating equipment; for instance, those devices that cut steam distribution costs in no way duplicate those that cut steam generation costs.

A Case in Point

In the heart of Chicago there is one of several cases which shows how one economy can be added to another as long as steps are intelligently taken. It also shows some real economies in steam utilization because the issue is not fogged, as is so often the case, by the simultaneous installation of both control equipment and combustion or generating equipment. In fact this particular building—the Consumers building at State and Jackson Sts.—purchases its steam from a district steam company and all economies produced can be readily and accurately obtained from meter readings. The story of this building is therefore interesting because it demonstrates, first, the possibilities of careful operation; next, the advantages of automatic operation, and finally, the combination of the two.

The Consumers building is the oldest user of purchased steam in Chicago. During the first years of operation with purchased steam it was described as a "devil to heat," but eighteen years ago George E. Lehner became engineer and things began to change. Up to that time a condensation meter had been used as a means of determining steam consumption. Operation of the system was changed from pressure to vacuum; rumor has it that the condensation volume dropped so rapidly that the steam company sent out sleuths to discover just where the condensation was being shunted off to the sewer.

Whether this is true or not is not established. It is given some fact, however, by the sudden substitution of a flow meter for the condensation meter, and although this proved that the condensation was not being spirited away, it also proved that careful operation was having its effect on heating costs.

Control Installed

Careful operation continued to tell, so that by 1930 the steam consumption per square foot of radiation was commendable. In April of that year, however, further economies were sought and a system for controlling room temperature by means of a combination of outdoor temperature and radiator temperature was installed.

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*Kreicker & Meloan, Inc., Chicago, Ill.

The control is located on the third floor near the last radiator of the system. The outdoor bulb is located on the east face of the building and is protected by a shield from the sun. Wires from the control run to an electric control motor near the pressure-reducing valve in the basement. A linkage from this motor shuts off the steam as demanded by the control.

Graph Shows Steam Consumption

What the control system has accomplished is shown in the graph. It is corrected for seasonal variation of temperatures by showing steam consumption in terms of degree days. It was also possible to segregate the water heating load; so the five graphs are true comparisons, uninfluenced by generating equipment and based on carefully checked flow-meter readings on which the steam billing was made.

The '28-29 graph and the '29-'30 graph show steam consumption before the control was installed, and the '30-'31, '31-'32 and '32-'33 curves were made since the control system went into operation. The total consumption during these heating seasons was:

1928-29	13,803,000 lb
1929-30	10,661,000 lb
1930-31	7,867,000 lb
1931-32	7,020,000 lb
1932-33	7,771,000 lb

Corrected to a degree-day basis the 1929-1930 season shows 1.715 pounds of steam per degree day, and the season following (under control) the consumption was 1.343 pounds per degree day. This indicates a net saving in steam consumption of 21.7 per cent. On a similar basis the saving during the 1931-32 season was 22.6 per cent, due to the better functioning of the system and the greater care with which it was handled.

Careful Operation, Control, Tell

The ideal degree-day graph is flat. That is to say, the consumption of steam in mild weather (per degree day) should be no greater than the consumption per degree day in zero weather. This is impossible of attainment but worthy of study.

In a building which purchases steam it is easier to handle the mildest part of the season because steam can be cut off manually without loss. This explains the valley during September and May in all curves but Curve *A*. In terms of the coal-fired or oil-fired system, however, these graphs become roughly representative from October 1 to March 31, and during those months the "automatic control" record is flatter and better. How automatic is it? Well, as was said, 21 per cent or 22 per cent better, but the graphs also emphasize the value of intelligent manipulation. Note, for instance, that Graph *C* has an indefensible rise during November, 1930, that shows the system was not being applied as effectively as it was later. The rise of Curve *E* during April, 1932, also shows that something went wrong.

All in all, this record shows that added savings can be made with proper control even in buildings where the engineer gives careful attention to heating efficiency—that these savings can be added to those made by generating equipment—that they are in direct proportion to the skill of application and operation.

Many Economies Made by Using Air Conditioning in Ripening Fruits

By **James J. Murray***

AIR conditioning plays an important part in the artificial ripening of tomatoes, bananas and other fresh fruits which are picked green and shipped to the point of consumption. A representative installation is in the Harry Becker Fruit Co. plant, Detroit, Mich., tomatoes and celery being the principal products handled.

In a well-insulated, air-tight room is installed the conditioning equipment. The 2200-cfm, 1725-rpm fan (driven by a ½-hp induction motor through a belt drive) recirculates the air within the room, drawing it from the ceiling and blowing it into the spray chamber, where it is conditioned and then discharged into the room beneath false flooring. In the flooring are many equally-spaced holes through which the conditioned air rises, passing through and around the stacked tomato crates to the ceiling where it again finds its way to the fan inlet.

The air in the room is maintained at 70-F dry bulb and 90 per cent or more relative humidity by means of a closed-contact thermostat and a closed-contact humidistat. A small amount of outside air is drawn into the room continuously to replenish the oxygen content of the room, the fruit absorbing oxygen during the ripening process.

When the outside temperature falls below the 70-F level, electric heating elements between the fan and the spray chamber supply the necessary heat. As the outside temperature rises above 70 F, the air is cooled by pulling it through a bank of ammonia coils of 3-ton capacity.

Flexibility is obtained by the use of a three-way plenum chamber on the fan inlet. Leading into this large cylindrical connection are a duct for the outside air, a duct from the refrigeration coils and an opening direct to the room. Each is dampered; thus, the fan

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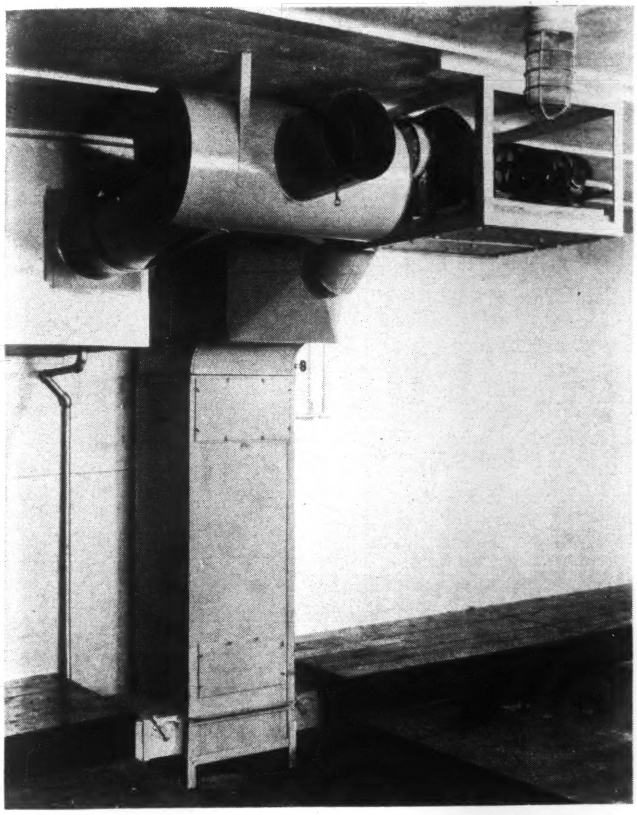
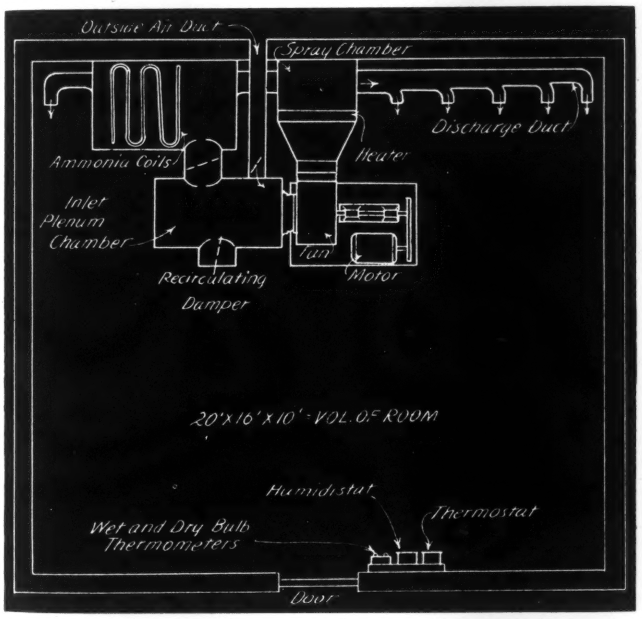
*From an interview with H. J. Somers, Inc., Detroit, patent owners, designers, and engineers.





Above—The air conditioning apparatus installed in the tomato ripening room. . . . Below—Plan of the ripening room layout, showing the ducts

can recirculate room air entirely, cooled air entirely, all outside air, or any combination.

The air washer is in the vertical chamber shown in the center of the photo. Inside are two spray nozzles, each discharging 10 gph of 130-F water. The spray removes dirt and objectionable odors from the air and, in addition, adds a certain amount of oxygen for absorption by the tomatoes.

By discharging the air along the floor line below the false flooring and allowing the air to filter up through the stacked tomato crates, even air distribution is obtained. With the system, the temperature difference between the floor and ceiling is less than ½ F. The discharge duct openings are designed to handle equal amounts of air, assisting in its even distribution.

Ethylene Gas Hastens Ripening

Ethylene gas (explosive) is introduced into the room during the ripening process as a coloring agent, hastening the ripening. The ethylene destroys the green pigment, or chlorophyll, in the unripe fruit, permitting the natural colors to appear, and also increases the sugar content by speeding up the oxidation of starch to sugar. The use of ethylene as a coloring agent puts a healthy red color on the rapidly ripened fruit which is favorably comparable to hot-house varieties, allowing the dealer to take advantage of early markets.

The gas is injected at the ceiling after the room has been loaded with fruit and closed. For each 1000 cu ft of room volume, 1 cu ft of gas is injected, the charge being measured through a calibrated valve on the outside of the room. The gas mixes readily with the conditioned air within the room, the mixture being recirculated for four hours with little outside air brought in. Then the room is opened and aired, the fruit inspected, the room again sealed and the procedure repeated. This cycle is continued until the fruit is ripe, the time usually required being from three to four days, depending on the condition of the fruit.

Advantages of the Conditioning System

Before the use of air conditioning, the fruit was stacked in a dark room, sprinkled as it was brought in and often covered with a wet blanket in an effort to keep the tomatoes damp. Air was circulated by small desk-type fans. When the room temperature fell below 60 F small gas plates were lighted to furnish heat. Results from this makeshift method were very uncertain; conditions in the room were unstable, the ripening process took three to four weeks, at the end of which there was a great amount of spoilage due to shriveling of the tomato skins and some still green fruit.

Simplified practice recommendation No. 25 covering **hot-water storage tanks** has been reaffirmed, without change, by the standing committee of the industry, according to the division of simplified practice of the *Bureau of Standards*. This recommendation, which was proposed and formulated by the industry, is concerned with the dimensions and capacities, working pressures, classification and marking, number of tappings, size of manholes, handholes,, and heating coils. It became effective originally in January, 1925.

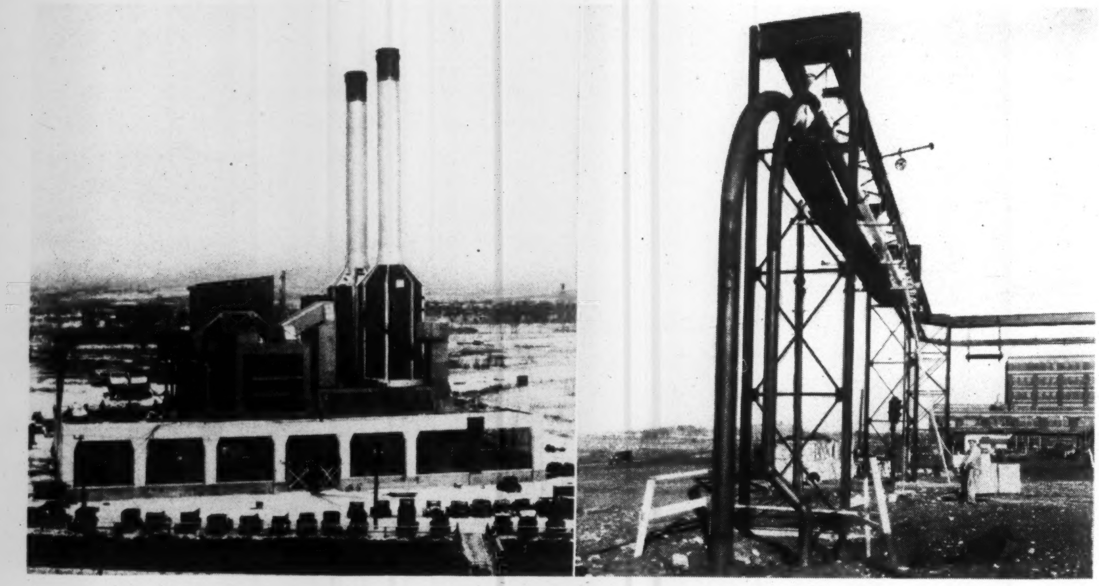
The Bureau also has announced that the standing committee of the industry in charge of simplified practice recommendation R28-29 covering **sheet steel** has reaffirmed the existing schedule without change. The sheet-steel recommendation is concerned with the various gages of galvanized flat, one pass cold-rolled box annealed, and blue annealed sheets.

*OF MUCH INTEREST is the new mercury-steam-electric plant at Schenectady . . . . So, too, is the arc-welded steam piping which distributes steam for manufacturing, heating, turbine testing . . . . . **The piping for this 400-lb, 750-F service is described in detail here.***

G. E.'s New Piping for 400-Lb, 750-F Service

Electric Arc Welded Throughout

By . . . .
Robert Daniels*



Left—South-side view of mercury-steam electric power station now nearing completion. Right—Steam and return pipe lines emerging from tunnel and passing to one of the bridges. Horizontal and vertical expansion is cared for by spring and point support hangers. The work of insulating the lines was facilitated considerably by the welded type construction used

A STEAM-piping system involving 4865 ft of 14-in. steam pipe, 4433 ft of 8-in., 10-in. and 14-in. condensate returns, and 3735 ft of tunnel and overhead bridge structure, recently has been installed in the General Electric plant at Schenectady, N. Y. The system will serve to convey steam for heating, turbine testing, and for manufacturing purposes from the new mercury-steam-electric generating station to distributing points in the two older power stations. This steam will be delivered at 400 lb per sq in. and 750 F and the lines will have a capacity of 500,000 lb per hr.

Electric arc welding was used throughout in the fabrication and erection of the pipe—both mains and returns, and all steel accessories—to minimize maintenance and insure a safe job for those in charge of operation. A number of economies were made and the installation has been successful in every respect.

New Steam Plant Nearing Completion

The new outdoor power station, nearing completion, will deliver its electric output of 26,000 kw to the commercial lines of the New York Power & Light Corporation and the steam output will go to the Schenectady Works, for purposes already mentioned. The 20,000-kw mercury-vapor boiler and outdoor turbine-generator will have a by-product steam output from its condensers and combustion chamber water walls of 330,000 lb per hr. A steam boiler will deliver an additional 300,000 lb per hr. A non-condensing 6000-kw outdoor steam-turbine generator is a part of the power station equipment. The available steam output—a half-million pounds per hour—will go to the Works, and all condensate will be returned to the new power station.

Steam and Return Lines in Tunnels

Most of the steam and return lines are carried in tunnels, although short sections where entry is made into Buildings No. 13 and No. 61 (the two older power stations) are carried on skeleton bridges because they cross trolley-tracks, a city water main, a street, the old Erie Canal, and other obstructions. Eventually, however, these obstructions will be removed and the bridges will be removed and the tunnel terminals completed.

The tunnel, with the exception of that entering the new station, is 8½ ft wide x 8 ft high, and is constructed of reinforced concrete having 10-in. walls. It was built about half in the ground, but the final grade will eventually be 2 in. above its roof. That section of the tunnel near the station is somewhat larger to accommodate the merging of all of the lines.

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*Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

The tunnel is drained by gravity to sewers, adequate lighting is provided, hatchways are available at 400-ft intervals and exhaust fans are similarly spaced. The lights may be switched on in either direction from the hatchways; the hatchways are large enough to allow 35-ft lengths of 14-in. pipe to be taken through them. Five exhaust fans will remove heated air and vapor, drawing fresh air through louvers at interpoints. These provisions are made so that periodic inspections can be made and work can be done comfortably and safely even in the event of a rupture in a steam line. The use of these fans facilitated welding operations, as a temporary ventilation system would otherwise have been required.

Fourteen-in. Piping Is Seamless

The 14-in. high-pressure piping is seamless, having ½-in. walls, and was supplied in 35-ft lengths, each weighing about 2300 lb. The pipe was delivered to the job with the ends beveled for welding. These lengths were tack welded together to form 200-ft sections and the welding of the joints was completed as the sections were rotated. These sections were then position welded to the stationary end of the expansion joints, thus completing the continuous line.

How Expansion Joints Were Installed

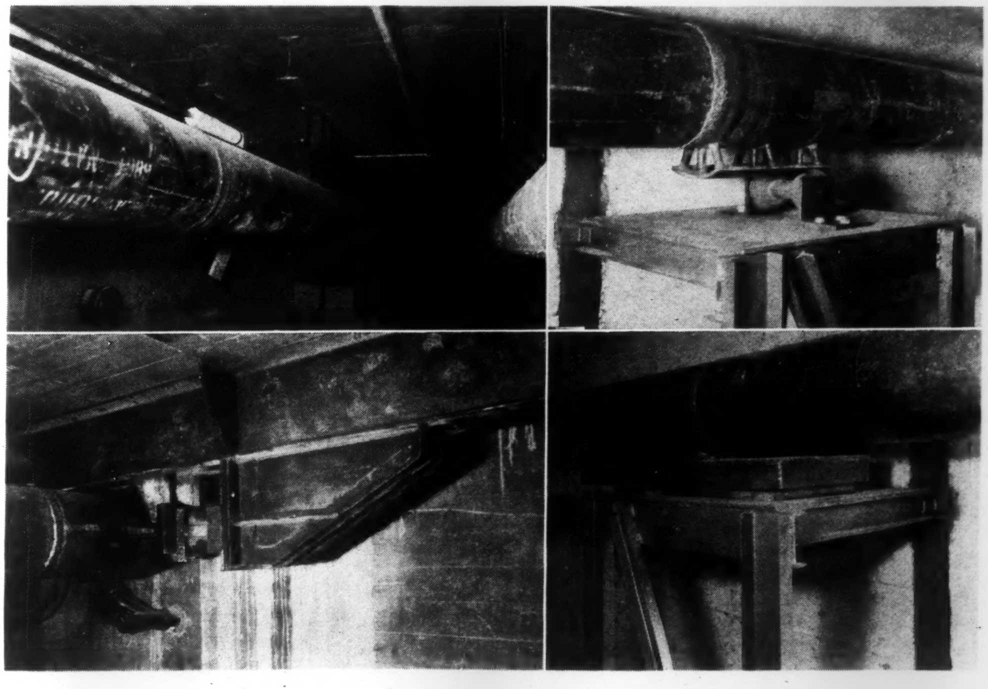
The expansion joints were welded to H-sections embedded in the tunnel side wall, thus providing a rigid anchorage. Self-sealing packing is used under light mechanical pressure. The seal is essentially completed by the steam pressure tending to press the truncated-cone rings against the pipe. The joint provides for 18 inches expansion, of which it is shown by calculation, from 14 to 16 inches will be required.

Located 12½ ft on each side of expansion joints are compound rollers of weld fabrication. One member is welded to the pipe, the other to a suitable structural steel support and three 2-in. cold-rolled steel rollers are placed between the members to care for longitudinal expansion. Twisting or swaying is prevented by vertical rollers. Spool type rollers are located at 25-ft intervals throughout the length of the pipe. The shoe that moves with the pipe is welded to the pipe through small pipe spacers, approximately 3 in. high, thus allowing space for insulation and minimizing heat transfer. The spool carrying member is attached to a table plate, which is supported by two channels embedded in the concrete wall and by structural legs and braces, which also carry the condensate return lines.

Directional changes are made through bends welded directly in the line; roughly, twenty-two 90-deg bends were used. The majority of these have radii of 1½ diameters, although those leading to the bridges are of 12-ft radii. Anchor brackets were attached by welding to the short radius turns and, in turn, to H-frames embedded in the concrete walls or roof. Where an expansion joint is located near an elbow, it is flexibly supported instead of being anchored.

Two Types of Pipe-Carrying Bridges

The bridges include two types of construction. The parts nearest the tunnel are built to carry the pipe by suspension, to allow for the expansion of the vertical runs. The suspenders are spring-supported on the bridge and are welded to rings which encircle the pipe and give it point support underneath, so that the pipe can move in three directions without imposing an extra strain on the bridge structure. The pipe next to the buildings is mounted on top of the bridges. A continuous H-section is laid between the bridge and the pipe, in order to relieve the structure of possible expansion strains. Should an expansion joint in the pipe fail to slip, the strain will be placed on the practically inde-



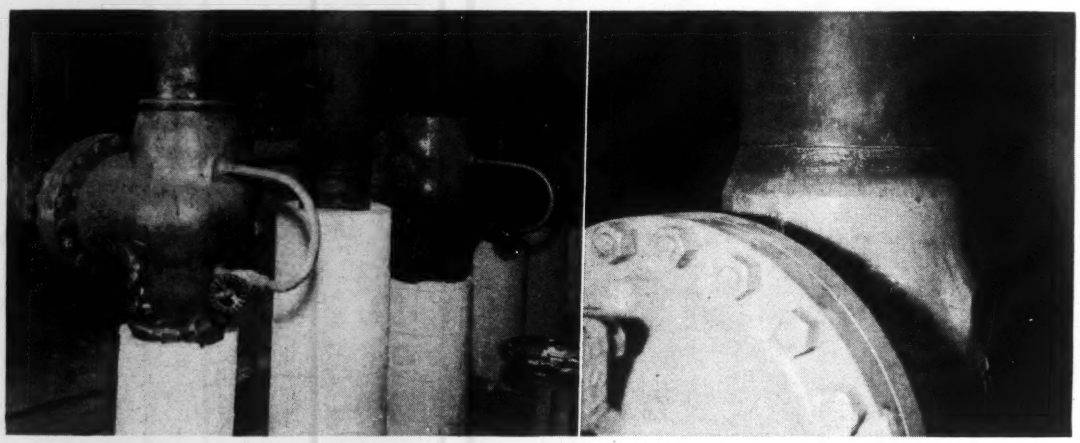
Top left—Suspension-type multiple roller support. This type of support is used near the new station for the conservation of space. Lower left—Combination anchor and expansion device for the 14-in. steam pipe line

Top right—Spool-type pipe support, spaced every 25 ft between multiple rollers and where overhead suspension is now used. Lower right—Multiple roller support of arc-welded construction. Designed to prevent side swaying as well as to allow longitudinal expansion

pendent H-section rather than on the bridge structure proper. The pipes are carried on multiple-roller supports spaced every 25 ft throughout these sections. The weld-fabricated bridges are constructed with expansion joints at regular intervals and are entirely independent of the pipes they support.

Distribution of the Steam

As stated, steam is delivered to two older power stations in the Works, Buildings No. 13 and No. 61, one pipe line to the former and two to the latter. In Building No. 13, the line branches to a 4000-kw, non-condensing turbine and to a reducing valve and de-superheater for furnishing manufacturing steam at 130-lb pressure. Exhaust steam from the turbine is used to heat office and factory buildings at one end of the plant. The return water is collected in a large reservoir which feeds by gravity to return water pumps, so designed and motored that they suit the output to the head imposed and require no manipulation to meet varying conditions.



Left—Vertical position pipe welds showing flangeless valves in the incoming lines to the main tunnel header. Pipes are (left to right) 12, 12, 18, 12, 12 and 8 in. in diameter. Right—Close-up of an 18-in. vertical position pipe weld at flange

The two high-pressure steam lines enter Building No. 61 at different points for operating condensing and non-condensing turbines of 20,000-kw output, and to furnish manufacturing steam. For a time, steam will be furnished to Building No. 61 at 225 lb and will be de-superheated at a location near the new power station. The exhaust steam from the non-condensing turbines goes to heat the buildings in that zone of the Works. Return water is pumped to an elevated tank in Building No. 61, from which it flows by gravity to the new power station. Return water from Building No. 13 joins that from No. 61 in the tunnel and also goes to the new station. In the event that the new station is not taking the water, No. 13 return goes to the tank in No. 61, hence the pumps in No. 13 do not have to be stopped or regulated. A check valve in No. 13 return line prevents a possible back flow.

Immediately upon completion of a portion of the high-pressure steam pipe, steam was sent from Building No. 61 to No. 13 and thus effected an economy by permitting the shut-down of boilers in Building No. 13. This necessitated immediate insulation of the pipes even before welding had been completed. The insulation was completed before the joints were tested, but upon applying the 225 lb of steam pressure available, no leaks developed.

In order that steam could be sent temporarily from No. 61 to No. 13, it was necessary to tie in one of the No. 61 lines with the No. 13 line at a point near the new power station. A 10-in. crossover (which will be removed as soon as the new station is ready to furnish steam) was welded in place near expansion joints.

Insulation of the Piping

The insulation on the high pressure steam lines consists of 1½ in. of high-temperature insulation and 2 in. of 85 per cent magnesia. A waterproof cover is wound around the insulation, being held in place by wire windings, and the whole surface is painted. Hinged copper jackets at the expansion joints permit removable covering at the joints with provisions for ventilation and drainage. A small vent collects and makes visible any steam leakage at the joint.

Erecting the Pipe in the Tunnel

The following is a brief description of the procedure followed in erecting the pipe in the tunnel:

Assembling 200-ft Section: After the stands for the expansion roller supports were fabricated and welded in place, the pipe was brought in through the hatchways and hauled in place on battery-driven industrial trucks. Fusion rings 1-in. wide by ⅛-in. thick were tack-welded in the outgoing end of each pipe, the welds being made at several spots at the inside edge of the ring within the pipe. Chain block hoists were then used to place the pipes on temporary dollies located on the roller stands. Six 35-ft lengths, with the last one cut to total approximately 200 ft, including the chromium-plated sliding section in the expansion joint, were rigidly tack-welded together at six points on the circumference of each joint. With the pipes thus assembled on dollies to permit rotation of the entire section, welding was started. To assure continuous welding without interruptions, a split gear was clamped on, and the 200-ft length was rotated at about one revolution in six minutes, or at a peripheral speed of about 7 in. per minute, by a small adjustable-

Table 1—Welding data for 14-in. O.D., ½-in. thick pipe for 400 lb per sq in., 750 F, steam service

TYPE OF WELD	ALLOWABLE WELDING TIME PER JOINT-HOURS	ELECTRODE CONSUMPTION, LB PER JOINT (CALCULATED)	POWER CONSUMPTION KWH PER JOINT (CALCULATED)
Roll (Pipe horizontal)	1.75	3.25	7.5
Position (" ")	4.0	3.25	7.5
Position (Pipe Vertical)	3.5	3.25	7.5

speed motor operating through a gear reducer and chain.

Roll Joints: Roll joints on the 14-in. diameter, ½-in. wall pipe, were welded in five passes, involving an equal number of complete revolutions of the pipe. Heavily-coated electrode was used for roll welds, starting with $\frac{3}{16}$-in. diameter electrodes at 200 amperes and finishing with ¼-in. at 275 amperes. The slag formation above the weld was thoroughly cleaned off after each pass. The first layer of weld metal deposited at the bottom of the 60-deg beveled joint was laid straight and the succeeding passes were oscillated as required to fill the groove. The last pass was approximately ¾-in. wide and slightly crowned.

Position Welds: A position weld was required every 200 ft in the line, being located at the intersection between the stationary end of an expansion joint and the receiving end of a 200-ft section. These position welds were made with $\frac{5}{32}$-in. heavily-coated electrode in four passes. The weld passes were started at the bottom of the joint and finished at the top, alternating the halves. Position welds on vertical risers were made by moving continuously around the pipe. Succeeding passes were started and finished at staggered points to prevent concentration of starting and finishing points.

The position welds marked the completion of joint welding and the roller dollies were removed and the permanent roller support members were inserted in place and welded. The expansion joints were then anchored by welding.

Condensate Returns: The welding procedure for the 8-in. and 10-in. condensate returns was much the same as outlined above, although the expansion joints were spaced but every 400 ft. The welds were made in fewer passes because of the differential of wall thicknesses. The 8- and 10-in. lines were of standard wall thicknesses.

Regular Production Welders Used

The welders who fabricated this piping were of the regular G. E. Schenectady Works production personnel. Over 30 welders in the Works have been qualified by the Hartford Steam Boiler Inspection & Insurance Company for welding Class *I* Pressure Vessels under the *A. S. M. E.* Boiler Code. Those welding on the pipe line were also required to qualify on roll and position pipe welds. Specifications covering in detail the entire welding procedure were rigidly adhered to throughout the fabrication of these lines. It is significant that not a single leak developed under steam test at 225-lb pressure, considering the great number of roll welds and horizontal and vertical position welds.

Welding 3% of Total Cost

An interesting fact is that the welding cost, exclusive of the tunnel and bridge construction, was but 3 per cent of the total cost. In addition, those in charge of the welding operations are confident that the allowable welding time values of Table 1 could be reduced considerably because of the experience gained by the entire personnel.

The responsibility imposed on the welded joints, the anchorages, the expansion joints, the insulation and the entire installation is made evident by the following figures. The total linear expansion involved in 4865 ft of 14-in. pipe for a temperature rise to 750 F is in the neighborhood of 30 ft with a potential expansion pipe thrust of 400,000 lb. In service, 2½ tons of steam are contained in the lines, traveling at a speed of 4000 fpm. The radiation at 750 F, without insulation, would be the equivalent of more than 20,000 kw, or the output of the mercury turbine.

Publishes Series of Booklets on Air Conditioning for Contractors

UNDER the auspices of its committee on air conditioning, the *Heating and Piping Contractors National Association* has recently completed and published a series of ten air conditioning lessons. These lessons are published in three parts.

Part One, containing the first four lessons, presents in simple form the fundamental information and engineering data which the contractor needs in the development of the air conditioning market. Part Two, containing the next three lessons, deals with the making of an air conditioning survey, the design and layout of air conditioning systems, and the selection of equipment for use in summer cooling. Part Three, containing the last three lessons and concluding the series, deals with the apparatus and equipment which is available, methods of selling it, and how to operate and service air conditioning systems.

These three parts, containing a total of 194 pages, together with a three-ring flexible imitation leather binder, are available for $5.00 for the complete set, from the *Heating and Piping Contractors National Association,* Rockefeller Center, 1250 Sixth Avenue, New York City.

Conventions and Expositions

Heating and Piping Contractors National Association: Annual convention, July 25-28, Chicago. Secretary, J. C. Fitts, 1250 Sixth Ave., New York City.

American Gas Association: Annual convention, September 25-29, Chicago. Headquarters Office, 420 Lexington Ave., New York City.

International Heating and Ventilating Exposition: Third exposition, February 5-9, 1933, Grand Central Palace, New York City. Charles F. Roth, Manager, International Exposition Co., Grand Central Palace, New York City.

These Two Jobs Show

Application of Electric Heating to Office Buildings

THE growth of electric heating shows that it has a logical place in the heating field for many applications. It has been successfully used for larger jobs than was originally supposed economically possible; this article describes two installations of electric heating in successful use in comparatively small office buildings.[1]

Both are located in moderately cold climates, one on the seashore at Wildwood, N. J., and the other in the mountains of eastern Tennessee, at Kingsport. Both have central heating systems with warm-air ducts and fan circulation, with heaters built into the ducts so that no floor space or useful area is taken up. Both are fully automatic.

One Building Is Air Conditioned

The Kingsport job has complete air conditioning with fans and washers located in the basement. A main ceiling duct contains the principal heaters and branch ducts have local booster heaters. The other job has no air conditioning. The fan is located in a small penthouse on the roof and the heating is done at the entrance to the five main ducts which lead from the fan to various parts of the building.

The Kingsport building is the general office of the Kingsport Utilities Co., an exceptional example of artistic design and fine workmanship. Allen Dryden (of Kingsport) was the architect and the materials used were almost entirely products of Tennessee, the outer walls of Tennessee brick and the inner walls faced with polished Tennessee marble.

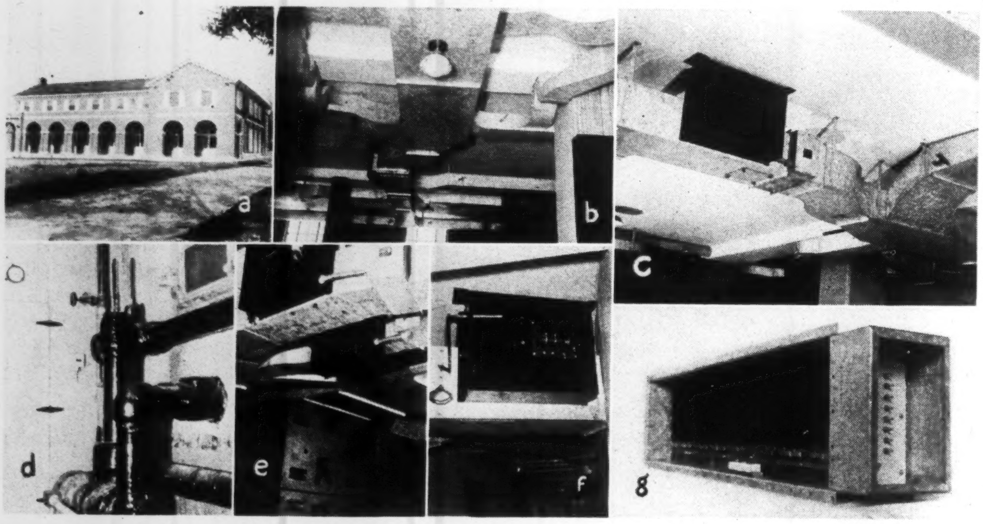
The first floor includes a beautiful foyer, used for display of merchandise. A much larger room, for receiving customers and transacting business with them, opens into it through marble archways. A marble stairway leads to the second floor, where the executive and engineering offices are located, as is a large auditorium for lectures, cooking demonstrations, civic and social community gatherings, etc. A stage is located in a recess at one end.

On the ground floor a rear entrance connects to a garage and service yard, the latter surrounded by a brick wall which harmonizes with the building and hides the service trucks and repair equipment from public view. The basement contains storerooms, a meter room, and a workshop for light repairs to household equipment. It also houses the air washers, fans, switchboards, and the deep-well pumps.

The Electric Heating and Air-Conditioning System

Because the auditorium is not used continuously, it has an entirely separate heating and cooling system similar to the main system with an independent fan, air washer, and ducts. This auxiliary unit can be put into operation at any time by merely pressing a control button. Considerable economy results from not operating this unit when the auditorium is not in use.

As the two systems are similar, only the one which serves the main building is described in detail: Fresh



The electric-heating and air-conditioning equipment in the office building of the Kingsport Utilities Co., showing, *a*, an exterior view of the building; *b*, main delivery duct from the fan; *c*, branch duct with individual booster heater; *d*, air washer supplied with cool water from a deep well; *e*, electric switchboards and some of the ducts with their control boxes; *f*, one of the synchronous control boxes with cover removed and the lever which regulates the dampers—manual adjustment of part of the dampers is provided and is also shown in this view. The eight-stage electric-heater unit for the main duct is shown in *g*

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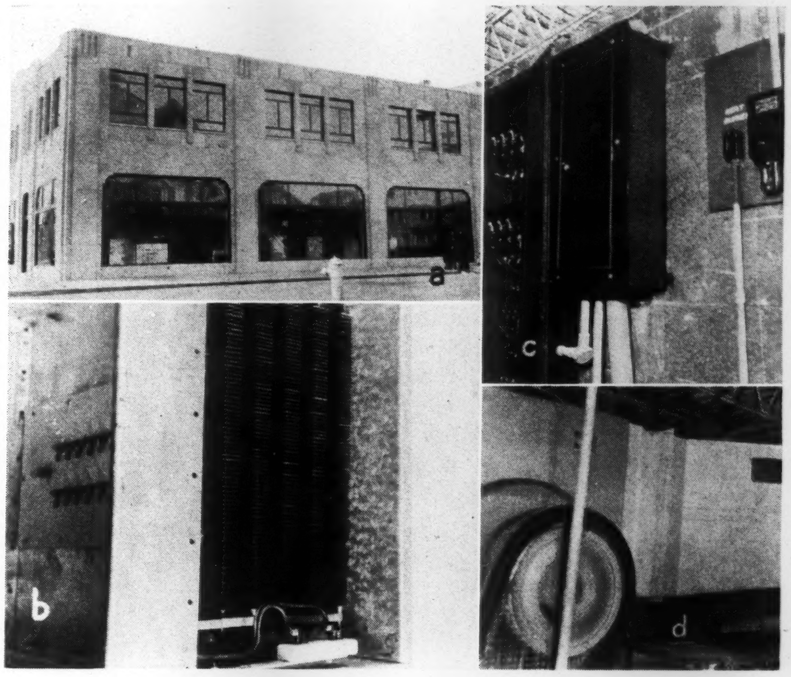
[1] For information on heating industrial plants electrically, see "Auxiliary Electric Heating With Off-Peak Power a Method of Cutting Cost," HEATING, PIPING AND AIR CONDITIONING, October, 1932, page 658.

By Lee P. Hynes*



The local office, *a*, of the Atlantic City Electric Co. at Wildwood, N. J., is heated electrically, the equipment being located in a penthouse on the roof. An interior of the penthouse is shown in *d*. The electrical control panels for the fan and heating system are shown in *c*, and *b* shows one of the heater sections. Capacity is 133 kw

air is taken from outdoors through an intake duct on the ceiling. In this duct is an electric-heating unit for tempering the incoming air. The tempered air then enters the washer and joins with the filtered recirculated air at the fan intake. From the fan it is distributed by a system of ducts to various parts of the building.

The electric heater for the main fresh air duct has large surface areas and runs at about the same temperature as a steam unit. It is arranged in eight balanced stages of heat which are automatically regulated according to both the temperature and the volume of the incoming fresh air. The control instrument for the fresh-air-duct heater is located in the water supply for the air washer, and the control instruments for the heaters in the circulation ducts are located in the rooms supplied by them.

The air washer is of a standard spray type. Cool water with a year 'round temperature of about 54 F is pumped from deep wells located under the building so that no mechanical refrigeration is needed. The return ducts discharge into a small room containing the air washer, fan, and pumps. The air is then drawn through viscous-type filters into the fan-intake duct. Dampers and heaters in the return duct automatically control the recirculation volume and the heat input. The control instrument is located in the discharge duct of the fan.

The main delivery duct from the fan is hung from the basement ceiling and branch ducts lead to various parts of the building. Booster heaters located in the branch ducts provide any extra heat needed at the particular location supplied. A damper is also located in each duct and the electric control synchronously regulates both the heat and the air volume, the control instrument being located on the wall of the room supplied. The automatic control system is entirely electrical and is completely interlocked so that no heat can be supplied unless the air is moving properly through the ducts. The heat input is always automatically proportioned to the room temperatures and to the volume of air flow in each duct.

The ducts are concealed in the walls, air being delivered through grilles near the ceiling except in the auditorium, which has special ceiling outlets. Return air is drawn into grilles located in the marble baseboard.

Accurate Temperature Regulation Saves Electricity

The climate in eastern Tennessee is colder than might be supposed; owing to the altitude it is quite similar to that of Pennsylvania or southern New York. Care was used to overcome excessive heat losses. A layer of 1-in. cork was placed in the walls between the brick and the marble and the windows were sealed to prevent infiltration. On sunny days considerable radiant heat enters and on cloudy days and at night, the large amount of waste heat which is always a byproduct of adequate illumination, is drawn into the circulating system. In winter it is useful for heating but in summer it is disposed of by the cooling system and discharged outdoors.

Because all unnecessary heat losses are avoided and all waste heat from the lighting is salvaged, and because the temperature is accurately regulated locally in each room, this building has been successfully heated with a low heater rating and has been operated at a satisfactory cost. The total maximum installed heat capacity is 410,000 Btu per hr. Approximately 75 per cent of this is in the main heating system and 25 per cent in the auxiliary system for the auditorium. With the auditorium not in use the maximum capacity is 308,000 Btu per hr which has proved to be ample for zero weather. Translated into electrical units, the main building system has an installed capacity of 96 kw and the auditorium system, 24 kw. With all the lights turned on nearly 30 kw of waste heat is recovered when needed.

For 150 days covering the five principal heating months (November through March) in 1932-33 an average of about 41 per cent of the rated capacity was used for the main building and 23 per cent for the auditorium. In this connection it is interesting to recall that with electric heating there is always approximately 100 per cent useful conversion of energy into heat units regardless of the load, so that there is no loss of efficiency when the operation is intermittent or the demand for heat varies.

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*Electric Heat Engineer, Philadelphia, Pa. Member of Board of Consulting and Contributing Editors.

Second Building Heated Only

The building at Wildwood, N. J., which is of reinforced concrete construction, is the local office of the Atlantic City Electric Co. On the first floor are the business offices and merchandise show rooms, and on the second floor is a large auditorium for public use. The heating equipment, the fan, the fresh air intake, and the air filters are located in a penthouse on the roof. This small penthouse compartment is the only space devoted to the heating system of this building. As the weight of the heating system is very small, no reinforcement was required to carry it on the roof.

Complete electrical control panels are provided for the fan and the heating system. The heat effect of the heater sections is divided into a number of stages regulated by an electric proportioning control which balances the heat-input capacity against the demand for heat, thus floating the heat load at the required amount rather than throwing it all on and all off at short intervals.

This building has an installed capacity of 133 kw which equals a maximum of about 454,000 Btu per hr for quick heating-up after week-end shut-downs. As the building is not used from Saturday noon until Monday morning, the main heating system is shut off, which results in a saving of power. The toilet rooms have small individual electric heaters under thermostatic control to prevent freezing of water pipes. In an electric-heating installation of this kind, the main heating system can be automatically controlled by a time-clock so as to govern the hours of heating as desired.

In this building the actual average heat-load demand for one complete heating season was only about 15 per cent of the installed capacity and yet the efficiency was uniform through the wide variation. This factor, coupled with economy through localized temperature control, helps overcome the energy cost of electric heat. There is also considerable saving in first cost of building construction and economy in space. The cleanliness of electric heat reduces the care and maintenance of air-filtering equipment.

The actual cost of operation is always of interest but with electric heat no general data comparable to fuel costs can be given because of the great variation in power rates. The larger the building, the less opportunity exists to utilize electric heating with economy, but for moderate-sized jobs it has many advantages wherever electric power can be purchased at sufficiently low rates to provide from 5000 to 10,000 Btu for each cent of cost for power. Even at considerably higher rates, it is frequently justified where its particular features are the main consideration.

Chicago World's Fair Proves
Air Conditioning Attracts the Public

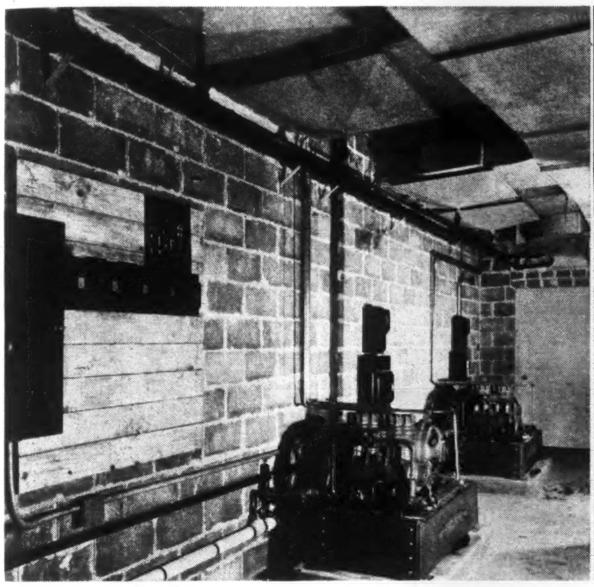
THAT cooled and comfortable air is an irresistible lure to the public on a hot day—and therefore a paying investment to stores and shops, restaurants and hotel dining rooms, theaters and other enterprises—is forcibly demonstrated at A Century of Progress International Exposition, the Chicago World's Fair. A number of auditoriums, exhibition spaces and other areas in various of the buildings on the grounds have been air conditioned to the advantage of attracting attendance.

One interesting case is the exhibit of the State of Michigan in the Hall of States. Dominating feature of this display is a replica of one of Michigan's beauty spots—Agate Falls on the Ontanagon River. Apparently from a painted back-ground, 500 gallons per minute of cooled water flow over the rocks toward the spectator. Equipment for cooling the water was originally supplied as it was expected to stock the pool at the foot of the falls with trout. However, it has been found that the falls is a crude air conditioner, cooling the air in the exhibit several degrees. On hot days this cooling effect has been so popular that the Michigan exhibit has enjoyed crowds which tax its capacity.

The compressor, the pump which recirculates the water, and the other mechanical equipment are located beneath a large relief map of the state which stands about 3 feet above the floor in the center of the exhibit.

300-Seat Theater Air Conditioned

Another popular spot is the Little theater in the General Motors building, which has become a hot-weather relief station to which thousands of persons have gone to obtain freedom from the heat and humidity of the outdoors. In early June, with outdoor temperatures ranging as high as 100 degrees, the house was filled at all times. The theater seats three hundred persons and is complete in every respect. Educational, entertaining



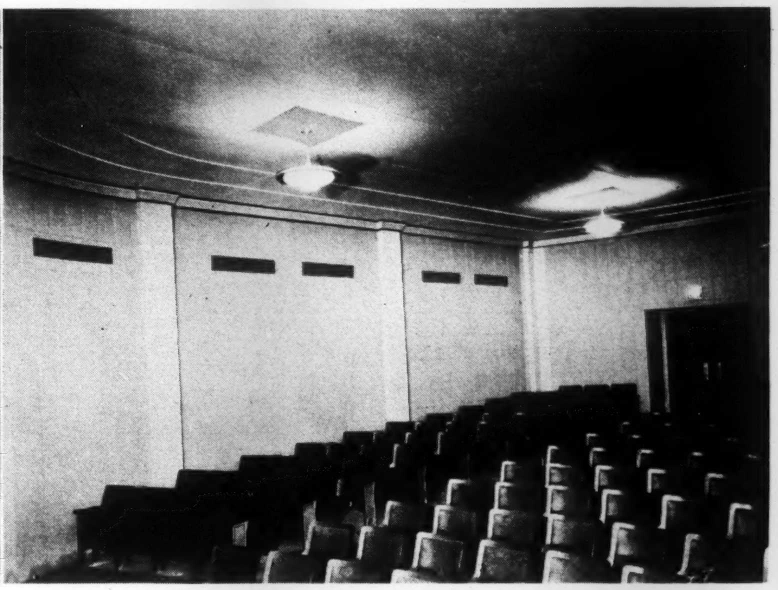


Fig. 1 (left)—Two of the 10-ton compressors which supply refrigeration for conditioning the theater in the General Motors building at the Fair. The cooling coils are in the ducts and the drain pans for moisture condensed from the air may be seen in this view. . . . Fig. 2 (right)—The Little theater in the General Motors building. Air is introduced to the auditorium through the wall grilles; is removed through those above the fixtures

and other types of sound motion pictures are shown thirteen hours a day.

The air-conditioning system is of the duct type with supply ducts located along the two side walls and the return ducts above the lighting fixtures. The refrigeration coils are located in the ducts outside the theater itself. Provision for draining excess moisture was made by placing drain pans beneath each coil. Maximum capacity is 34 tons of refrigeration, including three 10-ton units. Any one of the compressors, any combination or all may be in operation to meet the cooling and dehumidification requirements. All are thermostatically controlled.

The conditioned air is introduced through twelve grilles. New air is introduced to keep the indoor atmosphere fresh and invigorating at all times.

In addition to the theater, a large foyer and two dressing rooms are air conditioned. A combination duct and unit system is used, with the units recessed in the walls away from the traveled area. The rest of the building is conditioned by another system, a 120-ton CO_2 compressor being used.

Chemical Company Has Conditioned Display

An up-to-the-minute cooling system with little space for equipment and little time for installation were the architect's requirements for the Mallinckrodt Chemical Works exhibit. Practically the entire exhibit was completed. Instead of being concentrated in one room, it was in two rooms, with a broad hall or passage between them. It looked as if, with every available foot of space used, there could not be room for the necessary equipment anywhere in either room.

It had to be fairly large equipment, too. In figuring the cooling load, it was necessary to allow for the heat loss from an average of fifty persons. Something like 15,000 watts were figured for the many exhibit panels, moving-picture projection machines and indirect lighting system. There are, among the things that add to the cooling difficulties, 21 separate exhibit panels, each brilliantly lighted.

In the ether exhibit, in the north room, there are three moving-picture projectors and an ether still, with one outside glass door. In the south room there is a large revolving exhibit platform, or lecture table. Above this is another projector. The base of the platform is made up of a series of lighted panel exhibits, and there are several spotlights. Also in this room is a mercury still and a crystal sublimator in which is shown the manner in which iodine passes directly from the solid state to the gaseous, when heated. There is also a bunsen burner with a five-foot test tube.

Back of the revolving lecture platform there is a concentration of heat. Here are a number of fractional horsepower motors to take care of the demands of the equipment. On warm days the operator would find it very nearly unbearable. His comfort, and the motors, were taken into consideration in figuring the cooling job to be done.

Above the two rooms is one of the entrance ramps, ceiling of beaver board, and no possibility of insulation. There is also a heat gain from the space outside the two exhibit rooms. These rooms occupy opposite corners of two crossing halls or passages, with a kind of central foyer.

The architects, Pioso & Peterson, had completed their plans when it was felt desirable to provide air conditioning. Yet at only one point was it necessary to disturb in any way the original plans.

The first job was the locating of the compressor. There was only one place for it—under the floor, in a pit, below the space back of the revolving platform occupied by the operator. Into this pit was lowered the 10-ton, water-cooled four-cylinder freon compressor with its motor.

Cooling is accomplished by four 3-ton direct-expansion coils, two of which were installed just above the

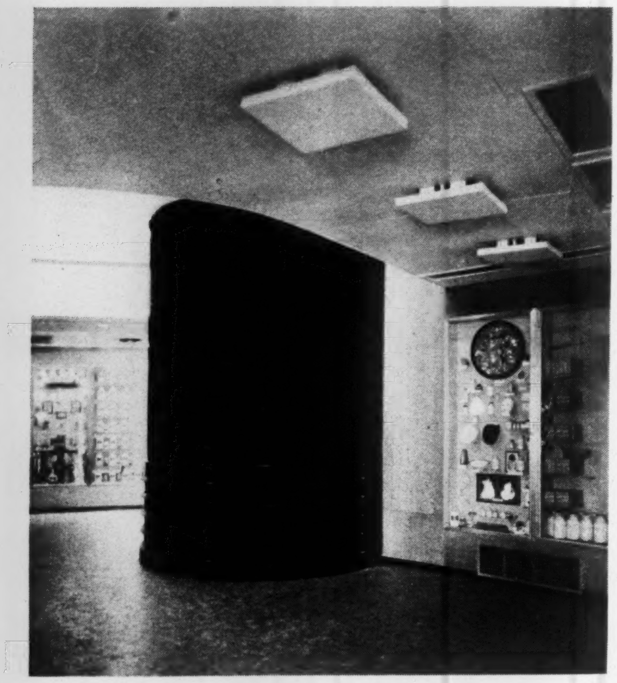


Fig. 3—A view of the Mallinkrodt Chemical Works display in the Hall of Science, which, because of the arrangement and the limited space, presented a problem to the designer of the air conditioning system

ceiling in either room. The 24-in. intake grilles were placed about a foot from the floor. The air is taken back of the display panels which form the walls, and rises to the ceiling. In each room there are two sets of three ceiling plates, through which the air is delivered by a 1500-cfm limit control, blower-type fan. These ceiling plates are adjustable. Air may be delivered equally on all four sides, or may be concentrated on any one side.

It will be noted that there is 12 tons refrigeration capacity in the coils, with the 10-ton compressor. The equipment has been installed so that each room will receive half of the cooling capacity, 5 tons, or one coil in either room may be cut out, thus giving 3 tons in one room and 6 in the other. Thus it is possible to produce a variety of conditions.

The space above the ceiling acts as the plenum chamber for a separate and distinct ventilating system. Since the compressor is located in the south room, the refrigerant for the coils in the north room is carried above the ceiling and over the hall. One air duct was installed to deliver a constant supply of cool air to the operator in his cubicle back of the rotating lecture platform.

It is a compact, effective installation, of which, for the visitors to the two exhibit rooms, the only visible parts are the ceiling plates and the intake grilles.

The operation of the equipment requires 660 gph of condenser water. This water is then drained into a sewer from the pit. From each of the four coils there is another drain, to take care of the condensation on the coils, leading to the same sewer.

While no specific dry bulb or relative humidity reduction was contemplated, the equipment gives about 10 F of cooling. The whole arrangement, manually controlled by the operator back of the lecture platform, is so planned that any desired combination may be secured. As explained above, he can shift the load from one room to another. He can cut out the compressor, on days when air motion is sufficient to provide comfort. On warm, dry days, comfort will be effected almost entirely by reduction of dry-bulb temperature. On extremely humid days, the comfort effect will be gained almost entirely by dehumidification.

This installation was designed by Roy Moffitt and installed by the Fairbanks Co., Chicago.

Acknowledgment for Figs. 1, 2, and 3 is made to the Frigidaire Corporation, Dayton, Ohio, and for Fig. 4, to the American Blower Corporation, Detroit, Mich.

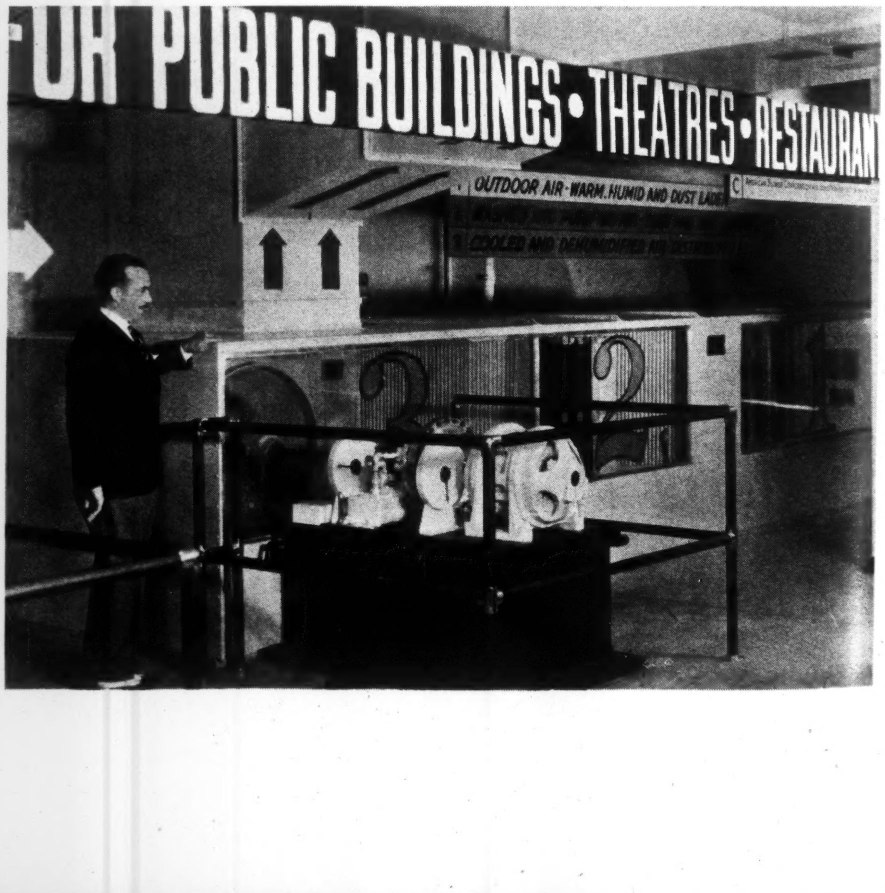
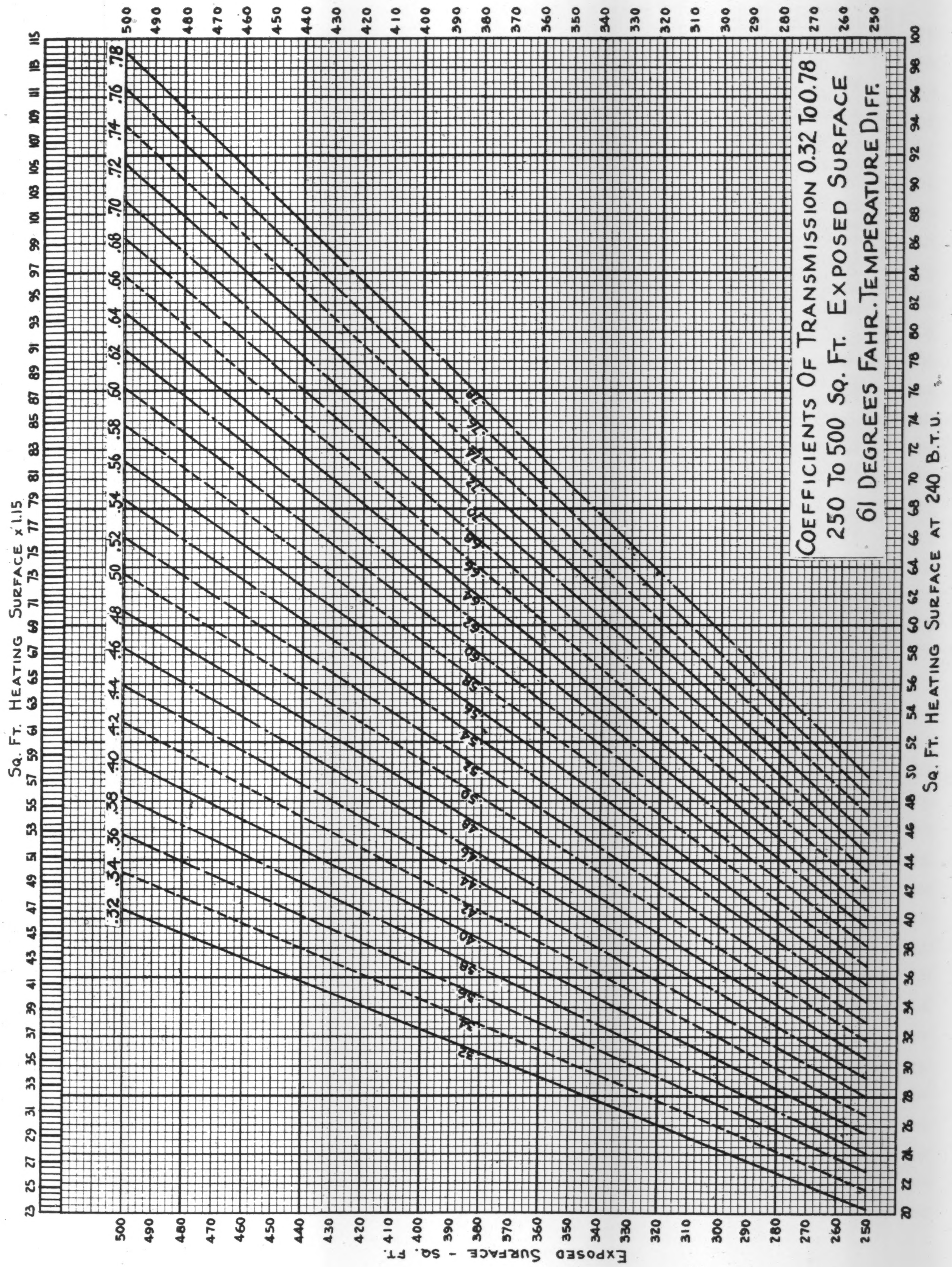

UR PUBLIC BUILDINGS · THEATRES · RESTAURAN
OUTDOOR AIR - WARM, HUMID AND DUST LADE
COOLED AND DEHUMIDIFIED
1
2
3

Fig. 4—Not only is air conditioning a public servant at the Fair; it is also on display. This exhibit consists of compartments of a large air conditioning system enclosed in glass so visitors may observe the process. The air is drawn into No. 1 compartment from the outside, pulled through a spray washer, and delivered to compartment No. 2. There it is passed through coils filled with water held at low temperature by a steam-jet machine and when it reaches the third compartment it is ready for circulation throughout the building. In the foreground is a hydraulic coupling, which makes possible a great variety of fan speed with a constant-speed motor

Calculating Heating Surface for Buildings 4

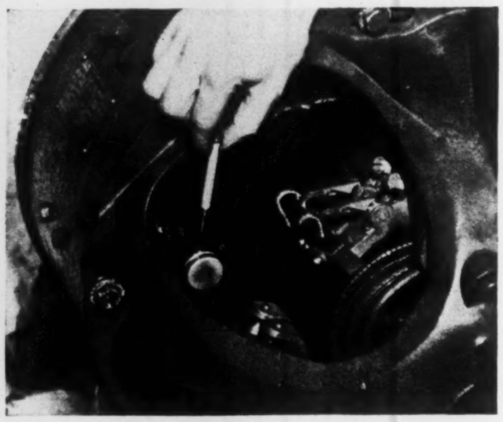
. . . . by Price L. Rogers, Consulting Engineer, Philadelphia, Pa. This is Chart No. 4 of a series designed to enable computations for heat losses from buildings to be made accurately, with a minimum of time and with decreased possibility of errors. Chart No. 1 and an explanation of the series and its use was published in April; Chart No. 2, May; Chart No. 3, last month.



INTERESTING Equipment..... Developments

Motors Have Built-in Thermostats

To give adequate protection against overheating in industrial motors, the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has announced a line of "thermoguard" motors, having a built-in disc thermostat that functions before the temperature of the insulation reaches the danger point. These motors may be arranged, at the option of the user, either to be disconnected from the source of power when the temperature approaches the danger zone, or to indicate by giving an audible or visible signal when an unsafe temperature is being approached. On processes where an enforced motor shut-down would cause a loss of product or other hazard, the motor will give advance warning that an emergency exists—and corrective measures can be taken. When desirable, the motors can be arranged to stop when their temperature is dangerously high and cannot be started until the operator manipulates the control. On unattended applications, it is possible to arrange the control so that the motor will automatically re-start when it has cooled to a safe operating temperature.



Induction motors so equipped are available in standard horizontal type, side mounting, fan cooled, explosion tested, vertical hollow shaft, enclosed or splash proof. The principle of built-in protection against overheating is applied to squirrel cage induction motors and wound rotor induction motors.

Direct-current motors of this line are designed for constant, adjustable, and varying-speed applications. They can be used for continuous or intermittent service for such drives as pumps, including those for mine service; fans; blowers, etc. Mill motors are designed for heavy-duty applications.

High-speed synchronous motors are designed with built-in protection against overheating for all types of constant-speed machinery such as fans, blowers, compressors, pumps, etc. Low-speed synchronous motors are adapted for driving low-speed machinery, such as pumps, etc.

There are several operating conditions from which motors should be guarded if motor investments are to be conserved, if maintenance costs are to be a minimum and if motors are to have maximum expected life. Among the most important of these are frequently repeated overloads, variable room temperatures, failure of ventilation, abnormal starting conditions. The new motors are designed to be self-protecting against these and other conditions which cause motors to overheat and burn out.

Announces New Conditioner

Buffalo Forge Company, Buffalo, N. Y., has announced a new comfort-cooler unit for room cooling and heating, called the "comfort conditioner." Designed chiefly for restaurant and office use, the conditioner is also suitable for use in stores, auditoriums, small theaters, etc.

Two extended-surface copper coils are provided—one for steam or hot water for heating, the other for cold water, brine, methyl chloride or freon for cooling. The heating coil can be omitted if desired.

The conditioner is made in three sizes, 2, 4 and 6-ton cooling capacity, with a Btu range of 24,000 to 72,000 per hr, average temperature drop of 28 F. Heating coils have a Btu range of from 77,500 to 232,000 per hr. Headroom required is 20 in.

The unit is fully enclosed so that no moving parts are visible. Piping connections are all made at the back. Casing is non-sweating, sound-absorbing insulating board, trimmed with metal angles and corners. The fans are a quiet, multiblade type driven by V-belt. Outlets are of sound-absorbing design.

New 10-Ton Compressors

A new series of condensing units for air conditioning has been developed by the air conditioning division of the Frigidaire Corporation, Dayton, Ohio, for approximate cooling capacities of 5, 7½, and 10 tons. (5, 7½, or 10-hp motors—the base is arranged to accommodate any of these motors built to N. E. M. A. standards.) The refrigerant used is freon, the charge for the 5-ton unit being 8 lb. and for the other two, 15 lb.

The compressors are of the four-cylinder, vertical single-acting, reciprocating type; bore and stroke, 3⅛ in. by 3⅛ in. Dimensions are width, 32 in.; length, 54 in.; height, 34½ in.

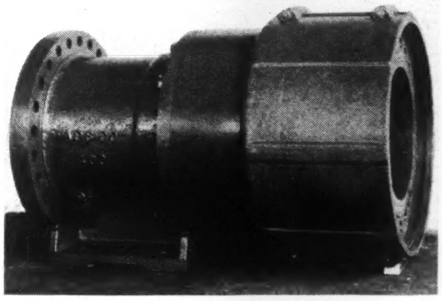
Slip Expansion Joints for 400-Lb

The American District Steam Company, North Tonawanda, N. Y., has developed a line of slip expansion joints for 400-lb W.S.P. The joints are of the internally-externally guided type provided with a specially designed anchor base. The chromium-plated steel slip is guided at both extreme ends throughout its entire travel to assure a straight and true movement of the slip. The greatest diameter of the joint is only slightly larger than the connecting flanges.

The internal guide feature consists of a ring fastened to the body end of the slip. This guide ring and the inside of the joint body are accurately machined to a close fit. This design of the internal guide keeps the slip free from the joint body and consequently prevents moving metal contact with the polished surface of the slip.

The external guide is accomplished through a hood, made in two pieces for ease of removal of either part when packing the stuffing box. The two parts are held in position by a bolted male-and-female joint. Both parts are bolted to the joint body with a male-and-female joint so that the guide will remain in its proper position.

The flange on the end of the slip serves both as a connecting flange and guide. It is larger in diameter than a standard flange



and is machined to fit the inner surface of the guide hood, which is also machined for the entire distance of slip travel.

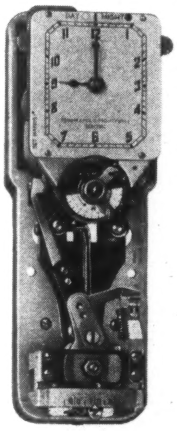
An inward limit stop prevents the slip from taking more than a predetermined amount of traverse. An outward limit stop prevents pulling out of the slip when the pipe contracts. The outward limit stop is a lip cast integral with the guide hood. A relief in this lip at the bottom of the guide hood permits any foreign matter, collected in the hood while the slip is in its inward position, to be pushed out by the guide flange.

The gland nuts are accessible after removal of the non-corrosive metal band which covers them. This metal band also protects the otherwise partially exposed surface of the slip. The gland studs and nuts are of non-corrosive metal and will not "freeze" in position, says the maker.

In addition to the flanged type of joint, either or both ends of the joint can be furnished with beveled ends for welding directly to the pipe line.

Control Combines Time, Temperature

A new instrument (the thermocron), developed by Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., combines time and temperature functions to make possible the *anticipation* of temperature changes without the aid of artificially applied heat at the thermostat. It takes the place of the conventional room thermostat, though in external appearance it is like the standard electric-clock thermostat which this company manufactures.



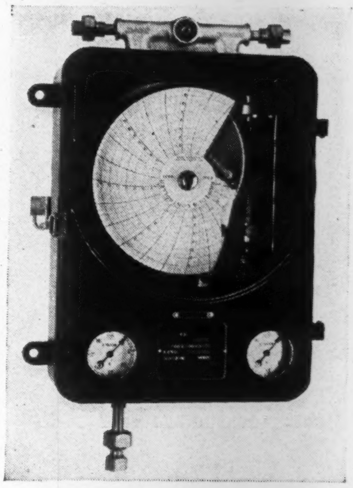
In its operation it is different from a thermostat because it combines the action of time and temperature. A fraction of a degree drop in temperature causes it to turn on the heat for a period of from one or two minutes to fifteen or twenty minutes, or continuously, depending upon the rate of heat loss from the building.

Because of its principle of action, this control constantly provides heat directly in proportion to the rate and amount of heat loss and so maintains temperatures within a fraction of a degree of the setting of the pointer to eliminate overheating, underheating and air stratification, according to the manufacturer. A new bulletin and complete detailed data are available.

New Process Controllers

The Bristol Company, Waterbury, Conn., has announced the introduction of new time-temperature and time-pressure controllers. In many processes, it is desired to regulate a temperature (or pressure) at some fixed rate, and then either hold it or decrease it at some other rate. These new controllers will do this, on any range of temperature from −40 to 1000 F, or pressure from 10 to 2000 lb.

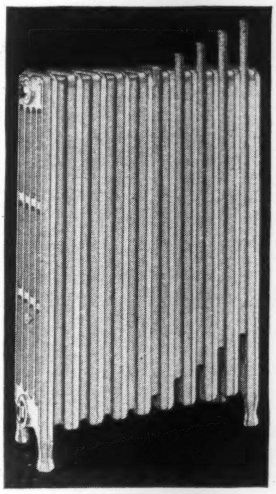
The illustration shows an exterior of one model of the new controller, large cam type. The cam consists of a graduated chart on sheet aluminum, that may be cut by the user to give any desired control characteristics. The cam is driven by either a telechron electric clock or by a spring clock. Air supply and control gages are mounted self-contained, and the whole is enclosed in a compact moisture-proof aluminum case.



Another model is similar to that illustrated, except that it is equipped with an indicating pointer which shows the instantaneous pressure or temperature at all times. The cam is of aluminum and is graduated so that the user can cut to any desired cycle. The use of a "free-vane" principle allows the instrument to control without restricting the indicating pointer. The cam is automatically driven and can be readily changed.

Shield Integral with Radiator

An invisible shield integral with the radiator has been introduced by Crane Co., 836 S. Michigan Ave., Chicago, and its application is shown in the illustration. The radiation is of the tubular cast-iron type—all heights, widths, and assembly lengths. The pressed-steel shield is easily applied to this radiation by slipping it between two specially-gaged beads on the rear tubes, until a tight joint is formed at the top hub. The shield does not detract from the appearance of the radiator.

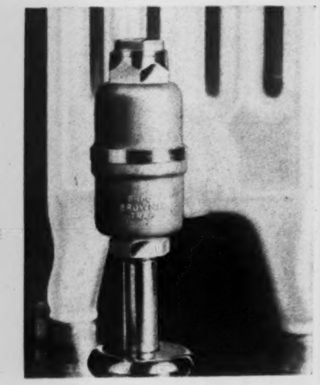


Advantages are low cost of installation, fuel economy, and elimination of dirt and dust on walls and hangings. The fact that the shield directs the heated air out into the lower portion, or living zone of the room, reduces ceiling temperatures to improve comfort conditions. Tests have indicated an average economy of 5 per cent in steam consumption, says the maker.

Introduces Vapor-Vacuum System

A new vapor-vacuum system has been introduced by the Brownie Company, Inc., North Arlington, N. J., and is designed to eliminate the central boiler-room traps and vents ordinarily used. It centers around a combined trap and air vent now available.

The functions of the trap, which is connected to the discharge of each radiator in the system, are to keep each radiator completely drained of condensate regardless of pressure or tempera-

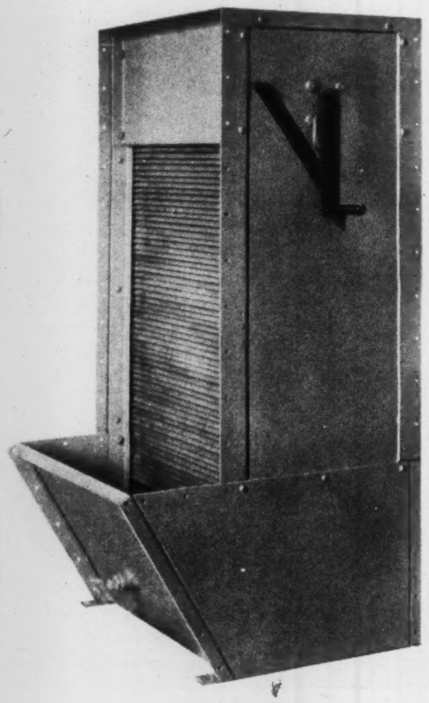


ture, to vent the air and other gases noiselessly and continuously from each radiator at all steam pressures above atmospheric and to prevent the re-infiltration of air to the system when operating at a vacuum under banked fire conditions.

The system is particularly adaptable to small heating installations such as stores, garages, shops and small factories with up to 10 or 12 radiators or unit heaters, according to the manufacturer, who has issued a bulletin describing it in detail.

Low-Headroom Air Filter

A new air filter designed to effect an important reduction in height, and therefore requiring less head room, has just been announced by the Independent Air Filter Company, 215 W. Ohio St., Chicago. It is of the impingement type, with an all-steel curtain which moves through an oil bath. The curtain is propelled by a motor, or manually.

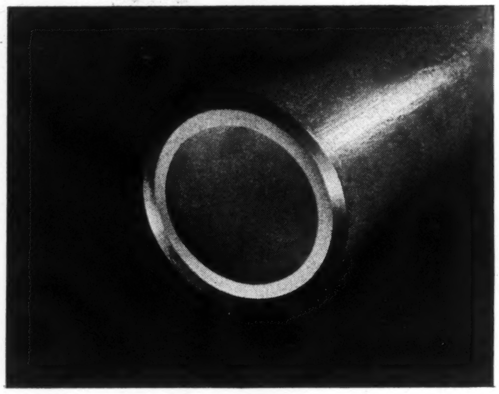


The illustration shows the adaptation of manual control, a feature which eliminates the motor drive. This form of control is practical on the smaller sized units ranging in capacity from 1000 to 4500 cfm, with motor drive preferred on the larger sizes, according to the manufacturer. With the manual control, the lever is pulled once or twice a week on the average job. This type is said to be especially adapted for air compressors, diesel engines and many small ventilating jobs, where its self-cleaning and constant effect features are desirable. A weather hood can be attached for outdoor installations. A recently-issued bulletin contains selection tables.

Pipe is Cement Lined

Intended for carrying waters or solutions which rust, corrode, or attack unprotected pipe the National Tube Company, Pittsburgh, Pa., has developed a cement-lined pipe which has many applications in industrial and building services, handling special chemical solutions, etc. Standard sizes range from ½ to 12 in.

The duroline lining was developed particularly for this purpose and is a material of low lime and high silica content that has less than one-third the solubility of ordinary portland cement mixtures, according to the manufacturer. Special manufacturing methods were developed also, and careful mill curing is given the lining.



The casing is made from the same steels and by the same methods used by this company for its regular black or galvanized wrought pipe.

Features of this pipe include smooth interior surface and good mechanical strength. The lining is not affected by rapid temperature changes or by long exposure to a temperature of 210 F.

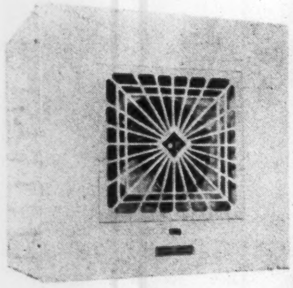
Special couplings with a compound developed for the application are recommended. Lead-lined fittings may be used when the ends of the pipe are properly faced. The pipe can be furnished with ends prepared for patented couplings, bell-and-spigot joints, or for flanged joints. It can be joined by welding if certain precautions are observed.

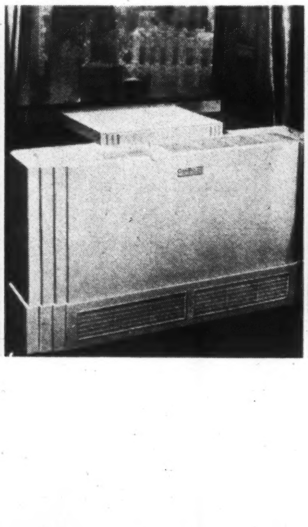
Line of Air Conditioners Announced

The air-conditioning department of the General Electric Company, Schenectady, N. Y., has announced the development of self-contained room coolers for summer air conditioning, portable, and floor and wall types; room coolers operating from remote compressors; a complete air-conditioning unit for conditioning air the year around; and a central air-conditioning system.

Functions of the room cooler are cooling, dehumidification, and circulation. The portable unit is mounted on rubber wheels, and is equipped with a 15-ft rubber hose line to be connected to a faucet, and 8 ft of electric cord to be plugged into a standard wall or floor socket. Dimensions are length, 43 in.; width, 13 in.; height, 33 in.; weight, 500 lb.

(To page 71, back Advertising Section)





Heating·Piping
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1895

American Society *of* Heating *and* Ventilating Engineers
JOURNAL SECTION

JULY *1933*

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The Application of the Eupatheoscope for Measuring the Performance of Direct Radiators and Convectors in Terms of Equivalent Temperature*

By **A. C. Willard†, A. P. Kratz‡, and M. K. Fahnestock§** ***(MEMBERS)***
Urbana, Ill,

This paper is the result of research conducted at the University of Illinois in cooperation with the* American Society of Heating and Ventilating Engineers' *Research Laboratory.

The data presented in this paper were obtained in connection with an investigation conducted by the Engineering Experiment Station of the University of Illinois, of which Dean M. S. Ketchum is the Director. This work is carried on in the Department of Mechanical Engineering. The results will ultimately comprise part of a bulletin of the Engineering Experiment Station. Acknowledgment is due E. L. Broderick, Research Assistant in Mechanical Engineering, for valuable assistance in the collection and preparation of the data.

In a previous paper[1] it was shown that a temperature of 68 F maintained at the 30-in. level in a room is a more acceptable standard for specifying the room temperature at which direct radiators and convectors shall be tested under service conditions, than 70 F maintained at the 60-in. level. It was further shown that when 68 F was maintained at the 30-in. level, any differences in heating effect, or effectiveness of the radiators or convectors in providing for human comfort, were directly reflected in differences in the steam condensation obtained. In this case, the temperatures were measured by means of thermocouples of No. 22 B. & S. gage wire, and the question arose as to whether any modification in the conclusions would become necessary if a sizable instrument more nearly approximating the proportions of the human body were used as an index of the combined effects of radiation and convection, instead of the comparatively small thermocouples that were actually used. Such an instrument, designated as an eupatheoscope, [2, 3, 4] has been developed by the Building Research Board in England. A similar instrument was, therefore, constructed, and further tests were run to determine whether the steam condensation of direct radiators and convectors could be correlated with the *equivalent* temperature as indicated by, and explained in connection with, the eupatheoscope, and whether any correlation existed between the readings of the eupatheoscope and the dry bulb temperature indicated by means of thermocouples made from No. 22 B. & S. gage wire.

Description of Apparatus

All tests were conducted in the West test room of the room heating testing plant. The latter has been completely described in previous publications.[1, 5, 6, 7] The location of the various instruments, and of the radiators or convectors as tested, is shown in the sections in Figs. 1 and 2. The thermocouples, borne by the standard at the center of the room, were made from No. 22 B. & S. gage wire and were placed at the levels shown in Fig. 2. A study of the temperature conditions within the test room proved that the center reading at a given level was representative of the average temperature at that

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*Presented at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Hotel Statler, Detroit, Mich., June, 1933.

†Professor of Heating and Ventilation and Head of the Department of Mechanical Engineering, University of Illinois.

‡Research Professor in Mechanical Engineering, University of Illinois.

§Special Research Assistant Professor in Mechanical Engineering, University of Illinois.

[1] A. S. H. V. E. Research Paper entitled Steam Condensation an Inverse Index of Heating Effect, by A. P. Kratz and M. K. Fahnestock, A. S. H. V. E. Journal Section (*Heating, Piping and Air Conditioning*, July, 1931, p. 621). Also (Reprint No. 1, Engineering Experiment Station, University of Illinois.)

[2] Department of Scientific and Industrial Research, *Report of the Building Research Board for the Year 1929*, His Majesty's Stationery Office, London, England.

[3] The Eupatheostat, by A. F. Dufton. (*Journal Sci. Inst.* 1929, 6, (8), pp. 249-51.)

[4] The Equivalent Temperature of a Room and Its Measurement, by A. F. Dufton. (Department of Scientific and Industrial Research. *Building Research Technical Paper* No. 13, 1932. His Majesty's Stationery Office, London, England.)

[5] University of Illinois Engineering Experiment Station *Bulletins Nos.* 192 and 223.

[6] Investigation of Heating Rooms with Direct Steam Radiators Equipped with Enclosures and Shields, by A. C. Willard, A. P. Kratz, S. Konzo, and M. K. Fahnestock. (Trans. A. S. H. V. E., Vol. 35, 1929, pp. 79-89.)

[7] A. S. H. V. E. Research Paper entitled, Performance of Convector Heaters, by A. P. Kratz and M. K. Fahnestock, A. S. H. V. E. Journal Section (*Heating, Piping and Air Conditioning*, April, 1932, p. 283.)

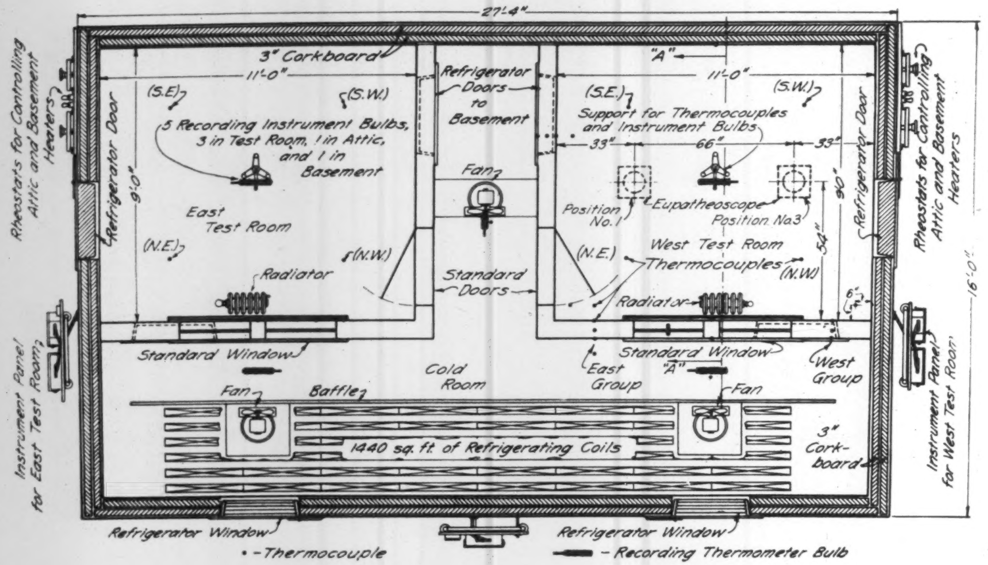
27'-4"
3" Corkboard
11'-0"
(S.E.)
(S.W.)
5 Recording Instrument Bulbs, 3 in Test Room, 1 in Attic, and 1 in Basement
East Test Room
(N.E.)
(N.W.)
Radiator
Standard Window
Fan
Baffle
Refrigerator Doors to Basement
Fan
Standard Doors
Cold Room
"A"
Support for Thermocouples and Instrument Bulbs
33"
66"
Position No. 1
Eupatheoscope
Position No. 3
West Test Room
Thermocouples
Radiator
Standard Window
East Group
West Group
1440 sq. ft. of Refrigerating Coils
3" Cork-board
9'-0"
54"
6"
16'-0"
Refrigerator Door
Rheostats for Controlling Attic and Basement Heaters
Instrument Panel for East Test Room
Instrument Panel for West Test Room
Refrigerator Window
Refrigerator Window
• -Thermocouple
▬ -Recording Thermometer Bulb

Fig. 1—Plan section of low-temperature testing plant

level. Most of the tests were run with the exposed walls containing a door and a window as shown in Figs. 1 and 2. For a few tests, however, storm sash and a storm door were installed, and sheets of ½-in. insulating wall board were attached to the window and door frames on the inside of the room, thus eliminating the window and door, and giving the effect of two unbroken exposed walls.

The direct cast-iron radiators used in these tests consisted of (1) a 9-section, 25-in., three-tube radiator having 1½ in. between the centers of the sections, (2) a 12-section,, 26-in., three-tube radiator, having 2½ in. between centers, (3) an 8-section, 26-in., five-tube radiator, having 2½ in. between centers, and (4) a 3-section wall type radiator, each section having a nominal rating of 7 sq ft. The convectors consisted of (1) three convectors with non-ferrous heating units, including two representative types, and (2) a convector with a cast-iron heating unit. The principal dimensions of the radiators and convectors are given on the insets in Figs. 6 to 9.

The Eupatheoscope

The principle underlying the eupatheoscope involves the measurement of the heat loss from a sizable body when the surface is maintained at some constant temperature. This implies the measurement of the amount of heat, or electrical current, required to maintain the surface at this same constant temperature.

The main element of the eupatheoscope used on these tests consisted of a hollow copper cylinder 7½ in. in diameter and 22 in. long, placed vertically on a stool so that its mean height was 30 in. above the floor, as shown in Fig. 3. Twelve thermocouples, made from No. 34 B. & S. gage copper and constantan wire, were embedded flush with the surface of the cylinder proper, which was blackened, and one was embedded flush with the surface of the top. These 13 thermocouples were electrically but not thermally insulated from the cylinder and were connected in series to a recording-controlling potentiometer, shown in Fig. 4, thus affording means of both indicating and controlling the average temperature of the surface of the cylinder.

In order to heat the surface, current from the line was supplied to a lamp-bank placed inside of the cylinder. This lamp-bank, removed from the cylinder, is shown in Fig. 3. The lamps, arranged as shown, in order to give uniform surface temperature, were connected in two separate circuits. Part of the lamps were supplied with a constant amount of current just insufficient to maintain the surface at the required tem-

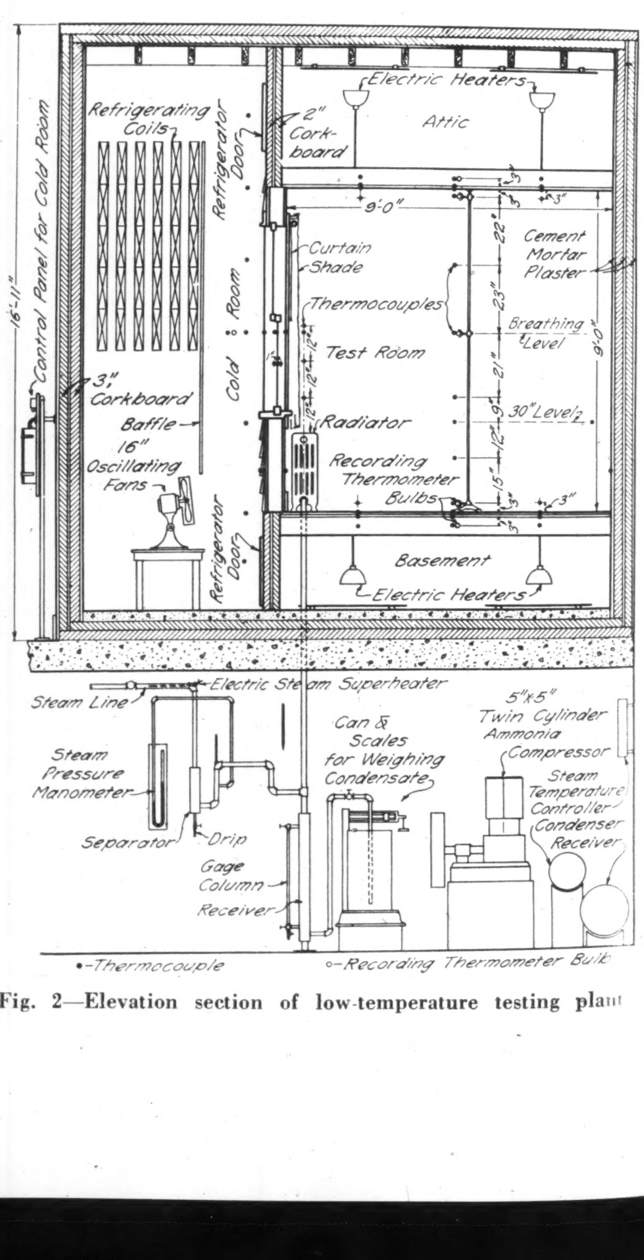
Refrigerating Coils
Refrigerator Door
2" Cork-board
Electric Heaters
Attic
9'-0"
3"
3"
Curtain Shade
Thermocouples
Test Room
Radiator
Recording Thermometer Bulbs
Cement Mortar Plaster
Breathing Level
30" Level
22"
23"
21"
9"
12"
15"
3"
3"
9'-0"
Basement
Electric Heaters
16'-11"
Control Panel for Cold Room
Cold Room
3" Corkboard
Baffle
16" Oscillating Fans
Refrigerator Door
Steam Line
Electric Steam Superheater
Steam Pressure Manometer
Separator
Drip
Gage Column
Receiver
Can & Scales for Weighing Condensate
5"x5" Twin Cylinder Ammonia Compressor
Steam Temperature Controller
Condenser Receiver
•-Thermocouple
○-Recording Thermometer Bulb

Fig. 2—Elevation section of low-temperature testing plant

perature. Current to the rest of the lamps was supplied intermittently through the action of the recorder-controller, thus maintaining the surface at the required constant temperature. The total current supplied was measured by means of a Lincoln thermal converter (Fig. 4) connected to a recording potentiometer. This arrangement proved satisfactory, but the necessity for using a step-up current transformer introduced difficulties in calibration that warrant the recommendation of a low range recording wattmeter for use in connection with similar eupatheoscopes.

Since human comfort is directly correlated with the rate of heat loss from the body, the eupatheoscope affords a means of evaluating probable comfort in terms of the heat required to maintain the cylinder at some constant temperature. The criterion provisionally adopted by the Building Research Board[2, 4] in England was based on observations indicating that in a comfortably warmed room a sedentary man loses by radiation and convection, neglecting evaporation as subsequently explained, approximately 17.5 Btu per square foot per hour, and that the average temperature of surface of the body and clothing is approximately 75 F. A room was, therefore, assumed to be comfortably warmed when the eupatheoscope loses heat at the rate of 17.5 Btu per square foot per hour with the surface temperature maintained at 75 F. This heat loss in a non-uniform environment may result from various combinations of radiation and convection, and, from the standpoint of comfort, it has been assumed that it is the rate of heat loss that is important, and not the relation existing between radiation and convection. Hence, the equivalent temperature of a given non-uniform environment has been defined as the temperature of a uniform enclosure, with walls and air at the same temperature, in which, in still air, a sizable black body at 75 F would lose heat at the same rate as it does in the non-uniform environment.

In its practical application, therefore, the eupatheoscope was calibrated by subjecting it to various temperatures in a uniform environment, in still air, with walls and air at the same temperature, and determining the rate of heat loss with the surface of the cylinder maintained at 75 F. These equivalent temperatures plotted against the rates of heat loss are shown in the lower calibration curve in Fig. 5. The heat losses observed in non-uniform environment may then be referred to this curve in order to express the combined effect of radiation and convection in the given environments in terms of the equivalent temperatures that would be required in a uniform environment to produce the same heat losses as those observed. The lower calibration curve shown in Fig. 5 agreed within approximately 1.5 F with the one published for the instrument used by the Building Research Board.[2]

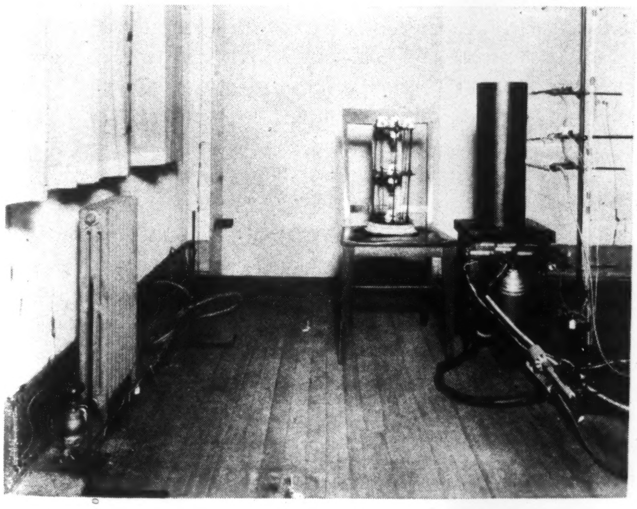

Fig. 3—The eupatheoscope with heating element removed

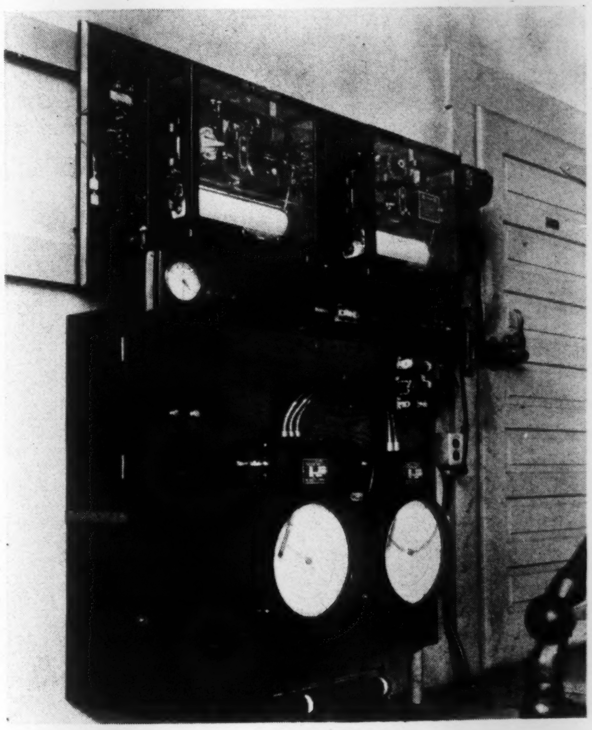

Fig. 4—Recorders and controller for the eupatheoscope

It may be observed that if a heat loss by radiation and convection of 17.5 Btu per square foot per hour with a surface temperature of 75 F is accepted as the criterion of comfort, the equivalent temperature conducive to comfort is 62.5 F. This, of course, corresponds to the dry-bulb temperature and not to the effective[10] temperature. Even at high relative humidities, a dry-bulb temperature of 62.5 F cannot be regarded as representative of American ideas or standards of comfort. Hence, it seems advisable to adopt a different definition of equivalent temperature to serve as a provisional standard more nearly comforming to American practice.

From the work of F. C. Houghten[8] and others, it has been established that the heat loss by radiation and convection from an adult, seated at rest in still air with 20 per cent relative humidity, is approximately 300 btu per hour. For an average man, with 19.5 sq ft of body surface, this is equal to 15.4 Btu per square foot per hour. Furthermore, from the work of L. B. Aldrich,[9] in which

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[8] Thermal Exchanges Between the Bodies of Men Working and the Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller, and W. P. Yant. (*The American Journal of Hygiene,* Vol. XIII, No. 2, March, 1931, p. 425.)

[9] A study of Body Radiation, by L. B. Aldrich. (*Smithsonian Miscellaneous Collections,* Vol. 81, No. 6, Dec. 1, 1928.)

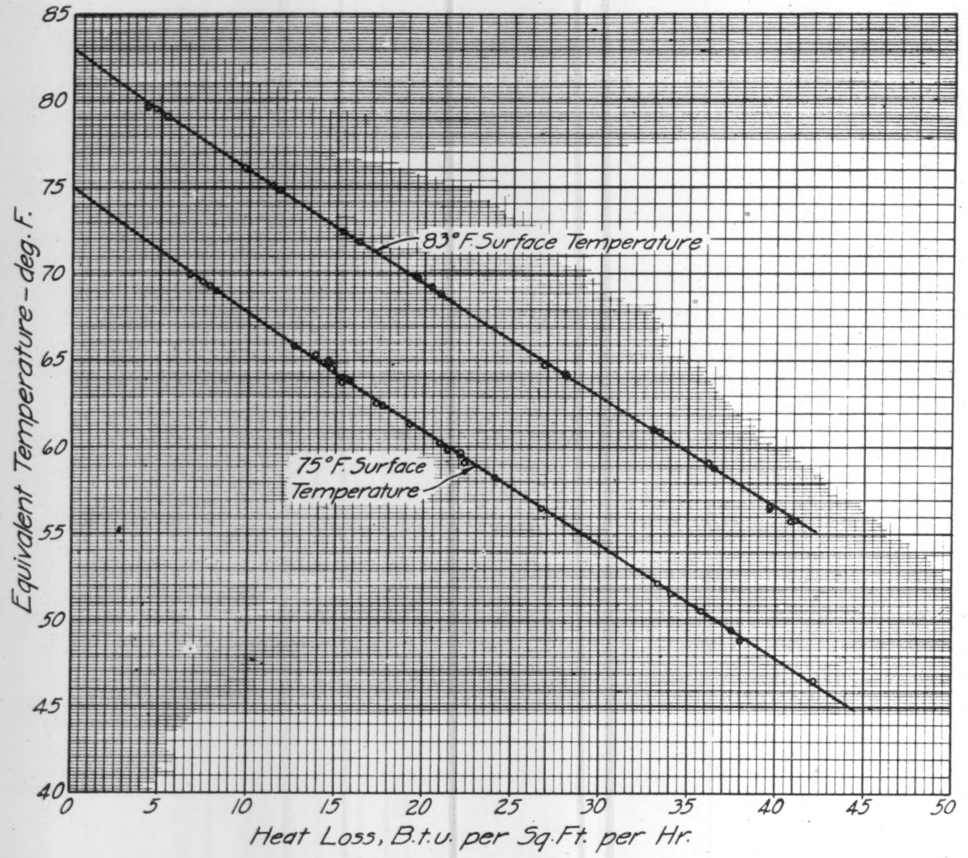

Fig. 5—Calibration curves for eupatheoscope

the measurements were made both with a modified form of bolometer and with thermocouples, the average mean temperature of the surface of the skin and clothing on a number of adults was determined as approximately 83 F. Hence, the eupatheoscope, as used in this investigation, was recalibrated with the surface temperature maintained at 83 F. The results of this calibration are shown in the upper curve in Fig. 5. From this curve it may be observed that with a heat loss by radiation and convection of 15.4 Btu per square foot per hour, the corresponding equivalent temperature is 72.3 F.

Extensive investigations made by the A. S. H. V. E. Research Laboratory and summarized in a paper by C. P. Yaglou,[10] have established the fact that for the average individual, at rest in still air under normal conditions of temperature and relative humidity, an effective temperature of 66 F is most conducive of comfort. The term effective temperature is not synonymous with equivalent temperature. However, since the measurements were made in rooms in which the temperature of the walls was practically the same as that of the air, the dry-bulb temperatures observed are identical with the equivalent temperatures as defined for the use of the eupatheoscope. With a relative humidity of 20 per cent, an effective temperature of 66 deg corresponds to a dry-bulb temperature of 73 F, and with a relative humidity of 40 per cent to a dry bulb temperature of 71 F. Hence, over the range of relative humidities practical for the average residence, an effective temperature of 66 deg agrees reasonably well with the equivalent temperature of 72.3 F shown by the upper calibration curve in Fig. 5 for a heat loss of 15.4 Btu per square foot of surface per hour. In the absence of more objective data, therefore, it is suggested that for American practice a room may be considered as comfortably heated when a sizable body at 83 F loses heat at the rate of 15.4 Btu per square foot per hour. This standard was adopted, and the upper calibration curve shown in Fig. 5 was used for all of the work on radiators and convectors reported in this paper. Since the two calibration curves are related through the equivalent temperature, the results can be converted to the English standard, if such a conversion is desired.

Since the eupatheoscope primarily determines the heat loss by radiation and convection alone, it is evident that some account must be taken of the effect of relative humidity in interpreting the readings. However, at normal relative humidities and at temperatures less than 75 F, small changes in relative humidity may be neglected in comparison with other factors. The work of F. C. Houghten[8] and others indicates a decrease of only 25 Btu in the total heat loss from an adult when the relative humidity changes from 20 per cent to 95 per cent at a constant dry-bulb temperature of 72 F. The relative humidity in the test room during the tests on radiators and convectors remained at approximately 15 per cent. Hence while interpretations of the results in terms of a standard of absolute comfort might be subject to modification, the readings of the eupatheoscope may be accepted as an accurate index of the relative performance of the different radiators and convectors judged on the basis of the environment established. The standard suggested is only provisional and somewhat arbitrary. A fruitful field of research is open in establishing an absolute standard in the light of actual physiological requirements, in determining whether the relation between radiation and convection is important in regard to human comfort, and in determining the modifications made necessary by changes in relative humidity. These considerations were definitely beyond the scope of the investigation of the performance of radiators and convectors.

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[10] How to Use the Effective Temperature Index and Comfort Chart. Report of the Technical Advisory Committee on Re-Study of Comfort Chart and Comfort Line, by C. P. Yaglou, W. H. Carrier, E. V. Hill, F. C. Houghten, and J. H. Walker. (A. S. H. V. E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, June, 1932, pp. 433-437.)

Test Procedure

In all cases, the temperature of the cold room was maintained at about —2.0 F, and one of the exposed walls was subjected to an equivalent wind velocity of approximately 10 miles per hour. The temperature of the air above the ceiling of the test room was maintained at 62 F and the air in the basement at such a temperature that the upper surface of the floor was approximately two degrees warmer than the lower surface. No test observations were made until conditions had remained constant for several hours, as indicated by the readings of the thermocouples on the inside wall surfaces. This required about 20 hours after a change in radiators or convectors was made. When the required thermal constancy had been attained, the condensate was weighed over the period of one hour, and no test was accepted if the condensate showed more than 2.5 per cent deviation in the successive 10-min increments of weight. At the end of each test, a separate test was run to determine the condensation in the piping alone, and the total condensate was corrected by subtracting the amount so determined, and by adding the steam equivalent of the heat given off by the eupatheoscope. The latter never exceeded 0.11 lb per hour.

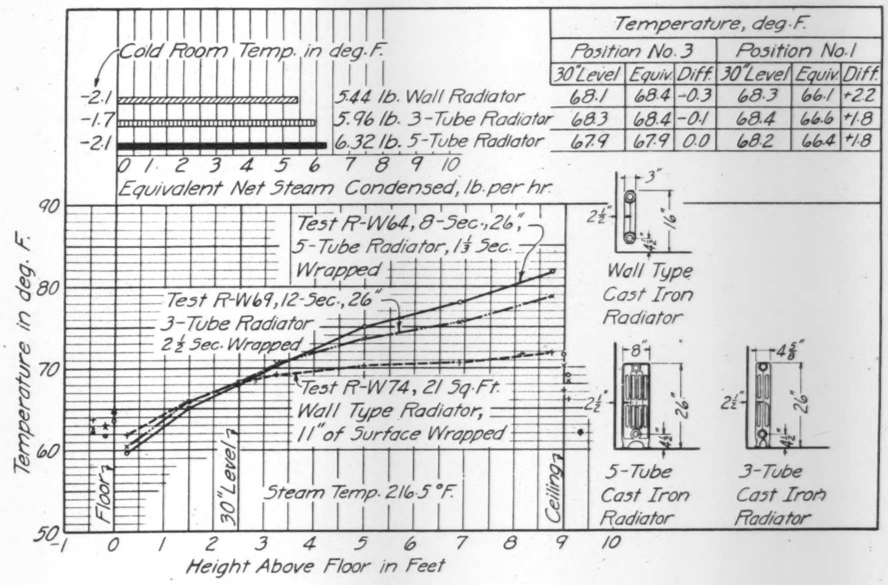
For one series of tests the output of the heating unit was adjusted, by wrapping part of the sections of the radiators or by blocking off part of the cabinets and heating units of the convectors, so that each unit maintained a temperature of 68 F at a level 30 in. above the floor. During each test, observations were made with the eupatheoscope placed either in position No. 1 or position No. 3 as shown in Fig. 1. The equivalent temperature obtained from the eupatheoscope readings was then compared with the dry-bulb temperature given by the reading of the thermocouple at the 30-in. level. Steam condensations were also compared under these conditions.

For a second series of tests, the equivalent temperature as indicated by the eupatheoscope when the 8-section, 26-in., five-tube cast-iron radiator maintained 68 F at the 30-in. level was adopted as a standard, and the outputs of all of the heating units tested were adjusted to maintain this equivalent temperature. The steam condensations were then compared under these conditions.

In order to determine the effect of doors and windows on the equivalent temperature, a few tests were run on one type of radiator and one type of convector, for which the door and window were blocked as previously indicated.

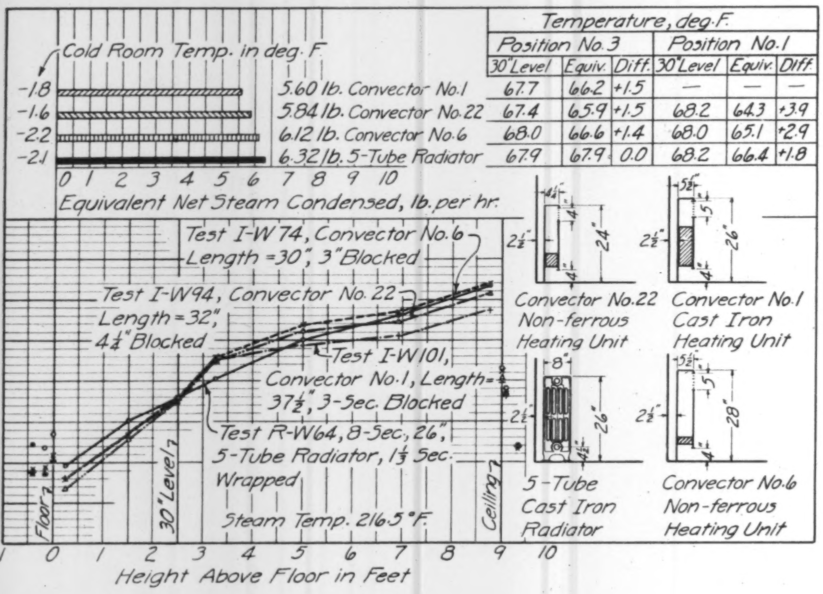
Results of Tests

The results of all of the tests are shown in Figs. 6 to 9. The tabulated values for the temperature at the 30-in. level with the eupatheoscope in position No. 3 all correspond with values read from the curves, which were established simultaneously with the eupatheoscope readings. Those for position No. 1 correspond with temperature gradients established on different tests at the same time that eupatheoscope readings in position No. 1 were made. Since it was impossible to duplicate the temperature at the 30-in. level within less than 0.5 F on successive tests, slight deviations appear between the two tabulated values for the temperatures at the 30-in. level obtained with the same radiator or convector. Since the eupatheoscope was less influenced by the presence of the cold exposed walls in position No. 3 than in position No. 1, position No. 3 was selected as the one on which to base all comparisons of the different heating units, although consistent comparisons could be made from the readings in position No. 1. The equivalent temperatures at the 30-in. level were all lower than the



	Temperature, deg. F.					
	Position No. 3			Position No. 1		
	30" Level	Equiv.	Diff.	30" Level	Equiv.	Diff.
5.44 lb. Wall Radiator	68.1	68.4	-0.3	68.3	66.1	+2.2
5.96 lb. 3-Tube Radiator	68.3	68.4	-0.1	68.4	66.6	+1.8
6.32 lb. 5-Tube Radiator	67.9	67.9	0.0	68.2	66.4	+1.8

Fig. 6—Room temperature gradients and equivalent temperatures for three types of direct C. I. radiators with a common 30-in. level temperature



	Position No. 3			Position No. 1		
	30" Level	Equiv.	Diff.	30" Level	Equiv.	Diff.
5.60 lb. Convector No. 1	67.7	66.2	+1.5	—	—	—
5.84 lb. Convector No. 22	67.4	65.9	+1.5	68.2	64.3	+3.9
6.12 lb. Convector No. 6	68.0	66.6	+1.4	68.0	65.1	+2.9
6.32 lb. 5-Tube Radiator	67.9	67.9	0.0	68.2	66.4	+1.8

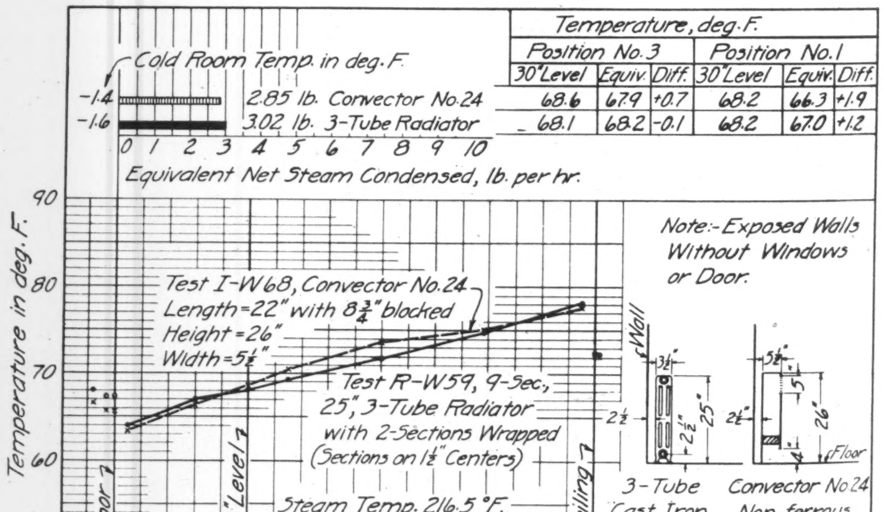
Fig. 7—Room temperature gradients and equivalent temperatures for a direct C. I. radiator and three convectors with a common 30-in. level temperature

72.3 F corresponding to an effective temperature of 66 deg. Owing to the higher temperatures above this level, however, the general effect was one of comfort, and, in most cases, if a higher equivalent temperature was maintained at the 30-in. level the room felt stuffy to a person moving about in it.

For the tests shown in Fig. 6 the three cast-iron direct radiators maintained a temperature of approximately 68 F at the 30-in. level, measured by means of a bare thermocouple made from No. 22 B. & S. gage wire. With the eupatheoscope in position No. 3 (Fig. 1), the equivalent temperature was practically the same as that observed with the thermocouple. The maximum difference of 0.3 F was obtained with the wall radiator and indicated that radiation was somewhat more effective in warming a large body than was reflected in the thermocouple reading. With the eupatheoscope in position No. 1, the equivalent temperature was consistently lower than that shown by the thermocouple, thus proving that the closer proximity of the cold exposed wall had an appreciable affect on the degree of comfort. Just why this effect was greatest in the case of the wall radiator is not apparent. The steam condensation corresponded to the effectiveness in heating as reflected by the temperature gradients. That is, using the condensation for the 26-in., five-tube radiator as a base the reduction in condensate for the 26-in., three-tube radiator was 5.5 per cent and for the wall radiator was 13.9 per cent.

The results obtained with three types of convectors with 68 F maintained at the 30-in. level as compared with the 26-in. five-tube direct radiator under the same conditions are shown in Fig. 7. It is evident from the eupatheoscope readings in position No. 3 that the convectors maintained an equivalent temperature approximately 1.5 F lower than that maintained by the direct radiator. This seems to indicate that some benefit results from direct radiation, particularly in the lower part of the room. It is also evident from the equivalent temperatures in position No. 1 that the proximity of the cold walls had more influence in the case of the convectors than in that of the direct radiator. The steam condensations are in the order that would be predicted from the temperature gradient curves. As compared with the direct radiator, convector No. 6 showed a reduction in condensation of 3.1 per cent, convector No. 22 of 7.5 per cent, and convector No. 1 of 11.4 per cent.

The effect of cold doors and windows may be shown by comparing Figs. 7 and 8. For the tests shown in Fig. 8, the door and windows were covered with insulating board. With the eupatheoscope in position No. 3, elimination of the door and windows had very little effect in the case of the direct radiator, but in the case of the convector the difference between the equivalent temperature and the dry-bulb temperature at the 30-in. level was reduced from approximately 1.4 F to 0.7 F, or 50 per cent, based on the comparison of convectors Nos. 6 and 24, which were of the same type. With the eupatheoscope in position No. 1, the elimination of the door and windows in the case of the direct radiator, reduced the difference between the equivalent temperature and the dry-bulb temperature from 1.8 F



	Position No. 3			Position No. 1		
	30" Level	Equiv.	Diff.	30" Level	Equiv.	Diff.
2.85 lb. Convector No. 24	68.6	67.9	+0.7	68.2	66.3	+1.9
3.02 lb. 3-Tube Radiator	68.1	68.2	-0.1	68.2	67.0	+1.2

Fig. 8—Room temperature gradients and equivalent temperatures for a convector and a direct C. I. radiator

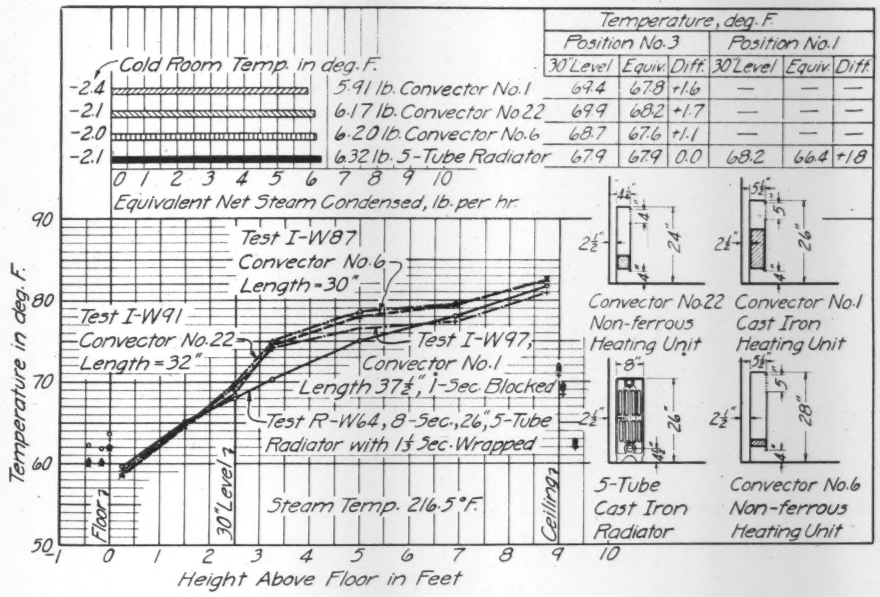


Fig. 9—Room temperature gradients and equivalent temperatures for a direct C. I. radiator and three convectors with a common equivalent temperature

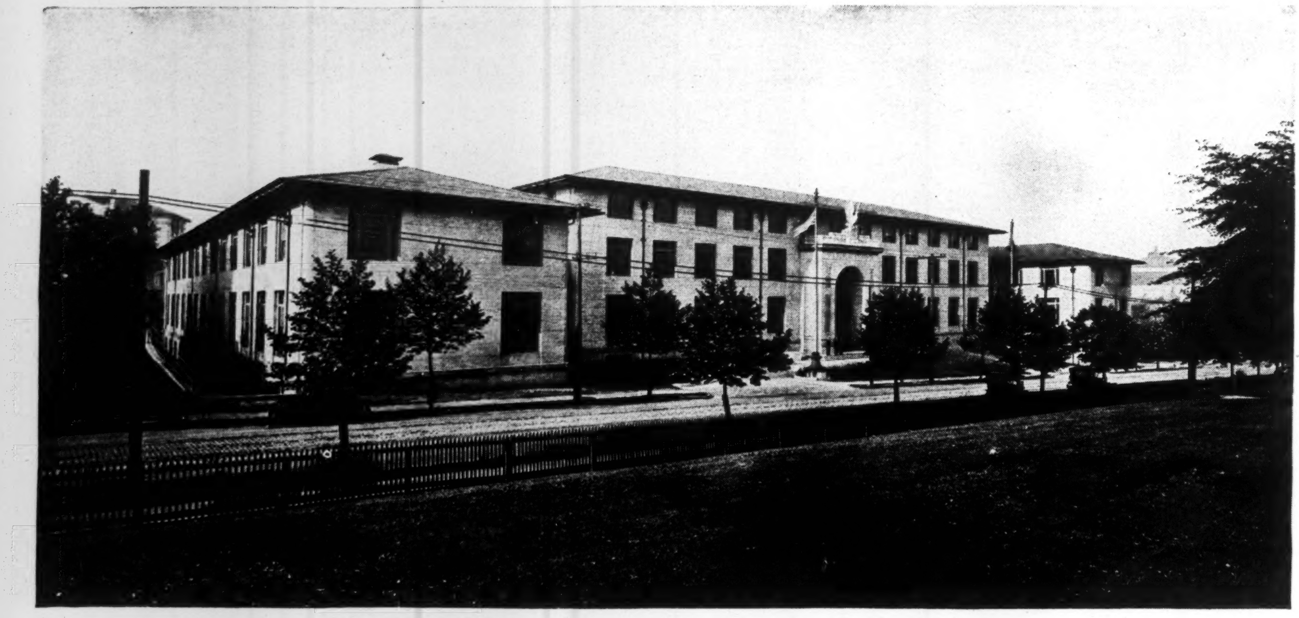
to 1.2 F, or 33.4 per cent, and in the case of the convector from 2.9 F to 1.9 F, or 34.5 per cent. The steam condensation cannot be compared because the units were of different size.

Since the results shown in Fig. 7 indicated that when the dry-bulb temperature at the 30-in. level was maintained at 68 F, the convectors produced an equivalent temperature less than that produced by the direct radiator, comparison of the steam condensations under those conditions might not give results truly representative of the relative heating effects. Hence, another series of tests were run for which the heat outputs of the different units were all adjusted to maintain the same equivalent temperature with the eupatheoscope in position No. 3. The equivalent temperature given by the direct radiator was selected as a standard, because in the previous tests with the direct radiator the equivalent temperature and the dry-bulb temperature at the 30-in. level were practically the same. The results of this series of tests are shown in Fig. 9. In this case, the dry-bulb temperature maintained at the 30-in. level by the convectors was approximately 1.5 F higher than 68 F. Expressed in terms of the steam condensation for the direct radiator, the condensation for convector No. 6 was reduced 1.9 per cent, for convector No. 22 was reduced 2.4 per cent, and for convector No. 1 was reduced 6.4 per cent. These reductions were less than the corresponding reductions of 3.1, 7.5, and 11.4 per cent obtained when a dry-bulb temperature of approximately 68 F was maintained at the 30-in. level. Hence, the conclusion expressed in a previous paper[1] that the steam condensation obtained when a temperature of 68 F is maintained at the 30-in. level is an inverse index of the heating effect in the case of convectors, is subject to slight modification in quantity but not in quality. Such a procedure would tend to credit the convectors with a heating effect somewhat too great. On the other hand, the difference is not so great as to invalidate the use of 68 F maintained at the 30-in. level as a simple and convenient criterion for testing convectors in order to obtain their relative worth from the standpoint of heating effect. The outstanding conclusion to be drawn from all of these tests, however, is that the maximum credit to be given to heating effect is probably in all cases less than 10 per cent, and the practice of increasing ratings anywhere from 10 to 30 per cent to allow for an extremely doubtful heating effect can hardly be justified.

Conclusions

The following conclusions may be drawn, governed by the conditions applicable to these tests:

1. The eupatheoscope affords a means of evaluating the combined effect of radiation and convection in a given environment in terms of a standard environment and in some terms related to human comfort.
2. As a provisional standard of comfort conforming to American practice, a room may be assumed to be comfortably heated when a sizable body at 83 F loses heat at the rate of 15.4 Btu per square foot per hour.
3. Future investigation should be undertaken to correlate the readings of the eupatheoscope with a more definite standard of comfort based on a consideration of all of the physical and physiological aspects of the problem.
4. The readings of the eupatheoscope serve as a means of ranking various heating units in the order of the relative heating effects produced.
5. The steam condensation obtained when the equivalent temperature is maintained at 68 F at the 30-in. level is a measure of the effectiveness of different types of heating units in providing for human comfort; lower condensations corresponding to greater effectiveness.
6. The steam condensation obtained when the dry-bulb temperature is maintained at 68 F at the 30-in. level is an approximate measure[1] of the relative effectiveness of different types of heating units in providing human comfort; lower condensation corresponding to greater effectiveness.
7. The heating effect is not materially greater than the total heat output as measured by steam condensation under given standard conditions, and the practice of adding a large proportion to the condensation rating in order to provide for heating effect cannot be justified.
8. The proximity of cold walls has an appreciable effect on the degree of comfort as determined by the eupatheoscope.



Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the American Society of Heating and Ventilating Engineers is located

Carbon Monoxide Distribution in Relation to the Heating and Ventilation of a One-Floor Garage[*]

By **F. C. Houghten**[†] ***(MEMBER)*** **and Paul McDermott**[‡] ***(NON-MEMBER)***

Pittsburgh, Pa.

THE ventilation of garages with a view of eliminating the carbon monoxide hazard with a minimum heating cost has received the attention of a Technical Advisory Committee of the American Society of Heating and Ventilating Engineers since 1928. The results of studies[1,2] made by the Research Laboratory indicated that upward ventilation was decidedly more effective than downward ventilation. Since they were made late in the heating season when the air used for ventilation was not heated, the Laboratory was asked to determine the extent to which the same characteristics prevail when heating as well as ventilation is required.

The present study was made in the same one-story single room Sheraden Garage, described in an earlier Laboratory report.[1] Briefly, this garage has a 52-ft by 60½-ft floor space with a 11¾-ft ceiling. Windows composed a large part of the walls above the 4-ft level on three sides. It was regularly used for storage and repair purposes and during tests was occupied to about two-thirds capacity. All tests were made after midnight, when complete control of the garage was turned over to the Laboratory staff.

Test Arrangement

For the purpose of the study a central fan heating and ventilating system was installed, incorporating the usual elements of such a system, with the added characteristic of flexibility, thus making experimentation on different methods of ventilation possible. This installation is shown in Fig. 1. A fan drew outside aid through a window and a heating unit and delivered it through an overhead branch duct system to points in the center of each quarter of the garage. From these points the air could be delivered to the garage with a relatively

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[*] Presented at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Hotel Statler, Detroit, Mich., June, 1933.

[†] Director, A. S. H. V. E. Research Laboratory.

[‡] Research Engr., A. S. H. V. E. Research Laboratory.

[1] Carbon Monoxide Distribution in Relation to the Ventilation of a One-Floor Garage, by F. C. Houghten and Paul McDermott. A. S. H. V. E. Journal Section (*Heating, Piping and Air Conditioning*), July, 1932, p. 495.

[2] Carbon Monoxide Distribution in Relation to the Ventilation of an Underground Ramp Garage, by F. C. Houghten and Paul McDermott. A. S. H. V. E. Journal Section (*Heating, Piping and Air Conditioning*), August, 1932, p. 559.

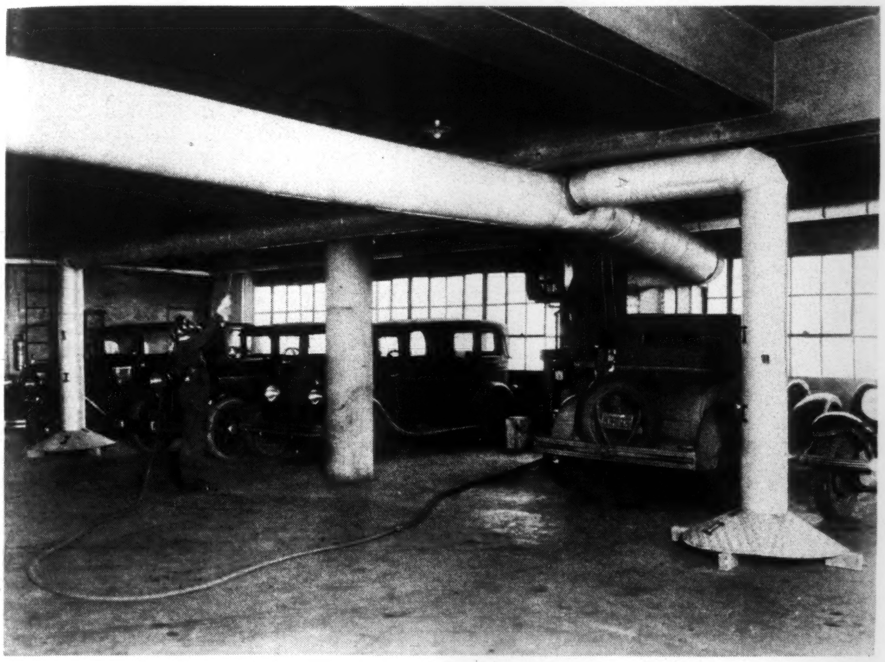


Fig. 1—Interior of garage, showing experimental central fan system arranged for upward ventilation

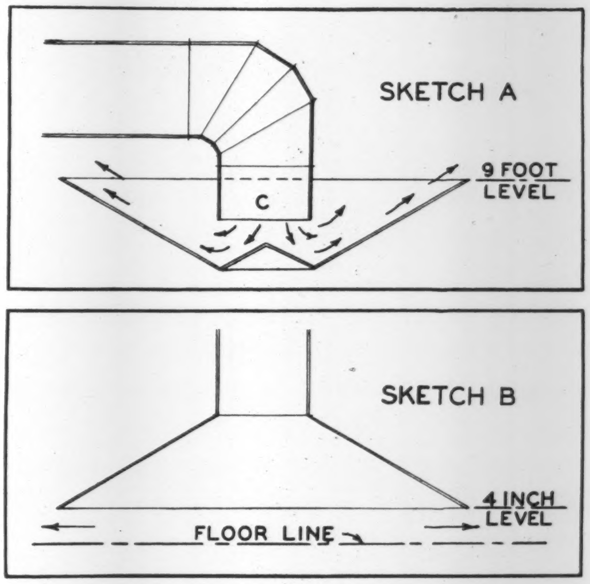
low velocity, either obliquely upward at the 9-ft level, as shown in Sketch *A,* Fig 2, or horizontally at the floor through a 4 sq ft opening, 4 in. wide, around the periphery of the cone, as shown in Sketch *B,* Fig. 2. Air was removed at either the ceiling or floor level through exhaust boxes located near the four corners.

For what is termed *upward ventilation* the heated air was supplied at the floor line as in Sketch *B,* and removed through the exhaust boxes at the ceiling. For *downward ventilation* the heated air was supplied at the 9-ft level as in Sketch *A,* and removed through the exhaust boxes at the floor line. In a third type, termed *modified upward ventilation* which was studied to a lesser extent, the deflector was removed from the end of the supply duct *C,* Sketch *A,* and the duct was extended down to the 8-ft level to allow the air to be projected from this point downward to the floor, whence it left the garage through the same exhaust box openings used for upward ventilation.

Regulation of fan speed and adjustment of the intake opening in the window allowed accurate control of the rate of air supply as indicated by a pitot tube permanently located in the main line duct. Control of distribution to the four points of air supply was provided by a damper in each duct branch. Control of the steam supply, variations in which were noted by changes in temperature in the main line duct, permitted the maintenance of desired room temperatures.

In all tests three automobiles with idling engines were placed to give as nearly uniform distribution of exhaust gases throughout the room as possible. Special care was taken that no exhaust pipe was directed toward any of the four sampling stations, which were spotted at representative points throughout the garage.

Preliminary to a test, the air supply and exhaust openings in the garage were adjusted for the particular type of ventilation and rate of air supply desired. The engines of the three cars were then started and the rate of steam supply was controlled to give air temperatures in the main line duct necessary to hold uniform the desired temperature at a control point 30 in. above the floor in the center of the garage. After the system had been in operation for at least an hour and constant conditions had prevailed for half an hour, samples of air for carbon monoxide analysis were taken at five elevations at each of the four sampling stations, and temperatures were observed at five elevations at two of the stations. Direct comparison of the methods of ventilation was aided by grouping into one night equal air change tests of upward, downward, and sometimes modified upward types.



Sketch *A,* downward ventilation
Sketch *B,* upward ventilation
Fig. 2—Methods of air supply to garage

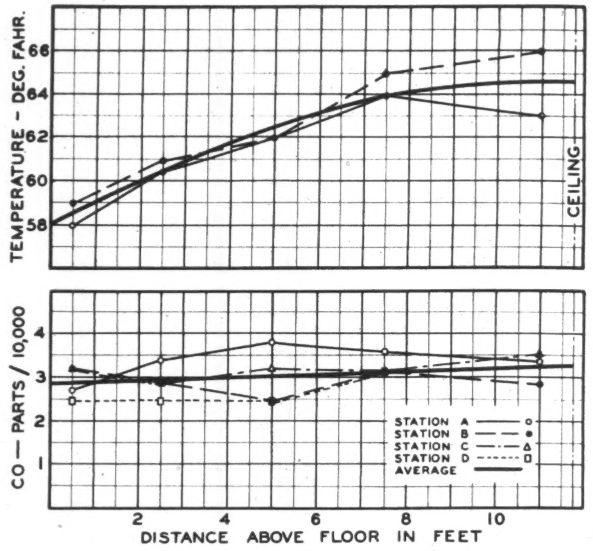
Test Results

Sixteen tests were made during January and February, 1933, with outside temperatures ranging from 8 to 40 F. The results of seven tests with *upward,* five tests with *downward,* and four tests with *modified upward ventilation* are tabulated in Table 1. These tests included over 640 air samples which were analyzed for carbon monoxide Variations found in data collected on different nights with the same type of ventilation and with the same rates of air change probably result from differences in wind velocity and direction, and in the throttle settings of the idling cars.

The results of a typical test are plotted in Fig. 3. Similar curves for all tests plotting carbon monoxide and temperature gradients from floor to ceiling show marked characteristics for the different types of ventilation when corrected to a common air change. In order to compare the carbon monoxide gradient curves for the three types of ventilation, they were corrected to an air change of 350,000 cfh per car. This rate of air change was accepted because an analysis of all data showed that the three idling cars gave an average rate of carbon monoxide production of 35 cfh, which with the accepted rate of air change and complete mixing gives a concentration of one part in 10,000. Incidentally, this represents 10 air changes per hour per car for the particular garage studied. The averages of the carbon monoxide gradient curves thus corrected are plotted for the three types of ventilation in Fig. 4. The temperature gradients expressed in temperatures above that at the 30-in. level are plotted in Fig. 5 for all upward and downward ventilation tests.

Discussion of Test Results

The carbon monoxide concentration gradients, plotted in Fig. 4, indicate that at the elevation of air exhaust the same concentration existed, regardless of the method of ventilation. In other words, downward ventilation shows a concentration at the floor about equal to that shown at the ceiling by upward and modified upward ventilation. However, concentrations at the floor and throughout the lower 5 ft, or occupied region of the garage, are lower for upward ventilation than for modified upward, in which concentrations are appreciably lower than those for downward ventilation. It is obvious that the concentration at the elevation of the air removal from the garage should be the same regardless of the type of ventilation with a given air change and a given rate of carbon monoxide production. But the fact that with downward ventilation the highest concentration is found at the ceiling is not obvious, for it might be expected that with warm air supplied at the ceiling and removed at the floor a reverse gradient would be had. However, as established in the earlier Laboratory



Data from Test *12; downward* ventilation; air change, 369,600 cu ft per hour; three idling cars; outside temperature 25.0 F

Fig. 3—Carbon monoxide and temperature gradients from typical test

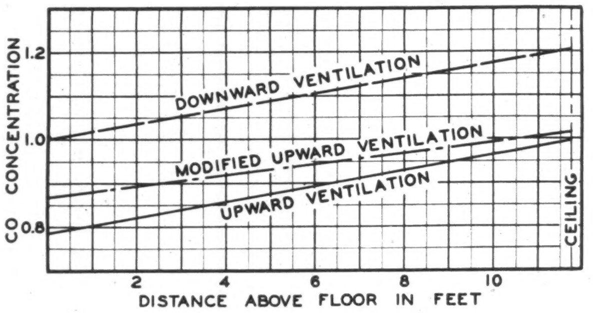


Fig. 4—Relation between distance above the floor and carbon monoxide concentration in parts per 10,000 of air. Average of all tests corrected to an air change of 350,000 cfh per idling car

Table 1—Data from Carbon Monoxide Study in Sheraden Garage

Test Number	Type of Ventilation	Air Changes		CO in Parts per 10,000 of Air				Garage Temperatures, F				Outdoor Temp, F	Rate of CO Generation per Car in cfh
				Observed		Corrected to 350,000 cfh Air Changes per Car		Distance Above Floor in Ft					
		Per Hour	cfh	0.5 Ft Above Floor	0.5 Ft Below Ceiling	0.5 Ft Above Floor	0.5 Ft Below Ceiling	0.5	2.5	5.0	11.0		
5	Upward	4.90	171,500	5.30	5.48	0.87	0.89	59.7	60.5	61.6	64.2	34.5	31.15
8	Upward	4.60	161,000	4.45	7.28	0.68	1.11	59.4	60.4	61.8	65.2	24.5	38.85
11	Upward	10.94	382,900	2.82	3.91	1.03	1.43	61.6	62.3	63.1	65.0	24.5	50.05
14	Upward	10.15	355,250	2.60	2.91	0.88	0.98	58.2	59.1	60.1	62.5	9.8	34.30
16	Upward	9.96	348,600	2.50	2.80	0.83	0.93	70.9	71.8	73.0	75.8	39.5	32.55
17	Upward	5.45	190,750	2.70	2.75	0.74	0.75	71.0	72.0	73.2	76.1	39.5	26.25
18	Upward	5.45	190,750	2.00	2.85	0.55	0.78	70.4	71.2	72.4	75.3	39.5	27.30
Average						0.797	0.981						34.35
2	Downward	5.53	193,550	7.45	7.90	1.37	1.46	64.8	69.2	73.1	75.8	37.0	47.95
6	Downward	4.83	169,050	4.60	5.08	0.74	0.82	55.3	59.3	63.3	67.2	32.0	25.90
7	Downward	4.92	172,200	5.00	4.30	0.82	0.71	57.0	60.0	63.3	67.4	25.3	28.70
12	Downward	10.56	369,600	2.91	3.22	1.02	1.14	58.5	60.4	62.4	64.6	25.0	35.35
13	Downward	9.95	348,250	3.30	5.50	1.09	1.82	56.0	60.0	63.7	66.5	8.5	38.15
Average						1.006	1.190						35.28
4	Mod. Up.	4.85	169,750	6.70	6.18	1.08	1.00	58.9	59.5	60.2	61.7	35.0	35.00
9	Mod. Up.	4.51	157,850	5.20	6.10	0.78	0.92	62.5	62.7	62.9	63.5	24.5	32.20
10	Mod. Up.	10.74	375,900	1.82	3.20	0.65	1.15	59.7	60.0	60.3	61.2	24.0	40.25
15	Mod. Up.	9.86	345,100	3.00	2.90	0.99	0.95	62.4	62.2	61.9	61.1	8.0	33.25
Average						0.875	1.005						35.18

reports, the hot exhaust gases from a car rapidly rise to the ceiling, in spite of ventilation. The characteristics of the carbon monoxide gradients as found in this study indicate an increase in concentration per foot of elevation practically independent of those at the floor.

Investigations[3] by the United States Bureau of Mines and others indicate that men should not be subjected to concentrations of more than 4 parts of carbon monoxide in 10,000 parts of air, and that no atmosphere with concentrations over one part in 10,000 should be considered safe for extended periods of time.

The concentrations of carbon monoxide found in the different tests with different rates of air change give rates of carbon monoxide production per idling car ranging from 25.9 to 50.1, with an average rate of 35 cfh per car for all tests here reported, which compares reasonably well with rates of from 27.6 to 34.8 found for the earlier Laboratory studies and with the rates of 31.0 to 39.2 for passenger cars and light trucks published[4] by the United States Bureau of Mines. Accepting 35 cfh, or the average rate of carbon monoxide production for all the tests made in this study, as a basis, calculations show that an air change of 350,000 cfh per idling car is necessary to give a concentration of one part in 10,000 when there is complete mixing of exhaust gases with air supplied. The curves in Fig. 4 are based upon this rate of air change. They indicate that in order to keep the concentration of carbon monoxide down to any accepted limit at an elevation of 5 ft, approximately 24 per cent more air must be supplied with downward ventilation than with upward ventilation. In other words, with one idling car an air change of 306,000 cfh is necessary to keep the concentration down to one part of carbon monoxide in 10,000 parts of air at the 5-ft level with upward ventilation, as compared to an air change of 380,000 cfh needed to keep the concentration down to the same limit with downward ventilation.

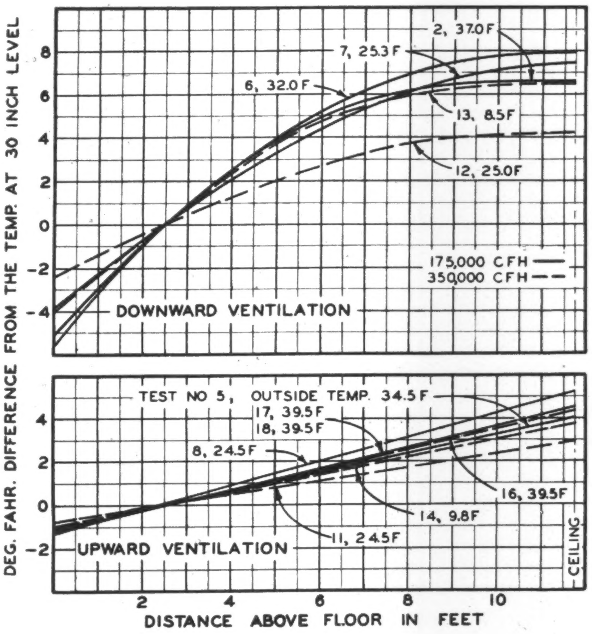


Fig. 5—Temperature gradients from floor to ceiling expressed in degrees difference from the temperature control point, 30 in. above the floor

Considering the vicious hazard incident to exposure to carbon monoxide, and the fact that the curves plotted in Fig 4 are averages of values showing considerable variation, one is reluctant to take advantage of the smaller air change, indicated as necessary by the upward ventilation curves, by using an air change of less than 350,000 cfh per car shown by computation for complete mixing. Since it would be difficult to insure the attainment of this advantage in all installations of upward ventilation systems, it would seem desirable to allow it to stand as a factor of safety and to ventilate with the upward method, and to supply air on the basis of complete mixing. It should be emphasized, however, that if this basis is accepted, a factor of safety of approximately 12.5 per cent can be expected with upward ventilation at the 5-ft level, while downward ventilation fails to give as good conditions as those resulting from complete mixing by 8.5 per cent.

Inspection of the temperature gradient curves in Fig. 5 shows rather definite relationships between the temperature gradients and rates of air change and outside temperature. The points for upward and downward ventilation in Fig. 6 were obtained by plotting the temperature difference between the 0.5-ft level and the 5-ft level against the temperature difference between the room control point and the outside. While the points are too scattered to allow the drawing of definite curves, they show a tendency for increased temperature gradient with increased temperature difference between the outside and inside, and a pronounced separation for the two types of ventilation.

Plotting the temperature gradient, expressed in temperature difference between the 5-ft level and the 0.5-ft level, against rate of air change gives the points in Fig. 7. While these points are rather scattered, they indicate a definite tendency toward a decreased temperature gradient with increased air change, and also a definite separation for the two types of ventilation.

The temperature gradient curves in Fig. 5 are steeper, particularly through the lower half of the room, with downward ventilation than with upward ventilation. The falling off of this gradient at higher elevations with downward ventilation probably results from the fact that the heated air was discharged with good distribution and mixing at the 9-ft level rather than at the ceiling. Since, with the same control temperature at the 30-in. level, the downward ventilation gives a higher air temperature next to the ceiling and upper part of the side walls, the heat loss from this part of the exposure and therefore for the entire garage must be greater. Hence, downward ventilation gives a less efficient heating effect.

No doubt, a heat balance made in conjunction with the study would have shown a considerably higher rate of heat input with downward ventilation than with upward ventilation for the same night, the same air change, and the same control temperature at the 30-in. level. Unfortunately, the demands on the garage would not permit running tests for a sufficient length of time to establish a constant and measurable rate of heat input, measured either by the rate of steam consumption or by the duct temperatures. While the duct temperatures do not give sufficiently consistent results to allow the development of a fixed percentage difference in heat input, they were consistently lower with upward ventilation. While the greater efficiency resulting from the better heating effect of upward ventilation cannot be numerically evaluated from the data presented, it must nevertheless be considerable, and when added to the possible saving in heat due to the lower air change leaves no doubt concerning the superiority of the upward system of ventilation.

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[3] Ventilation of Vehicular Tunnels, by A. C. Fieldner, Yandell Henderson, J. W. Paul, R. R. Sayers, and others. *United States Bureau of Mines Monograph I.* (A. S. H. V. E. JOURNAL, January-December. 1926.)
Also Bibliography in Carbon Monoxide Poisoning in Industry, Bulletin, Department of Labor, State of New York, 1930, pp. 231-238.
See also, discussion in references (1) and (2).

[4] Ventilation of Garages, by G. W. Jones and S. H. Katz. A. S. H. V. E. TRANSACTIONS, Vol. 29, 1923; pp. 341-346.
See also, references (1) and (2).

Probably in a garage more than in any other type of workshop, a uniform temperature from the floor to the breathing line is desirable, because men frequently must work under cars. Hence, because upward ventilation gives more uniform temperatures near the floor, it has an advantage in addition to the savings in heating load.

Practicability and Efficiency of the Upward and Modified Upward Systems of Ventilation

The particular shape of the cone outlet used with upward ventilation and the shape of the deflector used with downward ventilation should not be confused as a requirement in either of these systems. They represented a convenient way of obtaining the result desired, namely, upward oblique distribution of air near the ceiling in case of downward ventilation, and low velocity horizontal distribution of air over the floor in upward ventilation. Any other shape or arrangement of outlet satisfying these essentials should give identical results. In the upward ventilation system the outlet succeeded in giving an air stream in the form of a sheet reaching to the boundary of each quarter of the garage supplied by each individual opening. In a practical installation this requirement should be considered essential in attaining similar results.

Modified upward ventilation indicated results only slightly less effective than those shown for upward ventilation. It is possible that application will prove this method more practicable, regardless of the slight superiority of upward ventilation. Certainly, modified upward ventilation can be installed with less difficulty and will offer less interference in the practical use of a garage. However, it is probable that contingent factors met with in practice would result in less certainty that the results found in this study would be obtained with modified upward than with upward ventilation. Obviously, the outlets with modified upward ventilation must be so designed that the air stream will carry to the floor and spread. A single car standing below an opening would defeat the effectiveness of such a system.

Summary and Conclusions

1. Upward ventilation results in a lower concentration of carbon monoxide at the breathing line and a lower temperature above the breathing line than does downward ventilation, for the same rate of carbon monoxide production, air change and the same temperature at the 30-in. level.

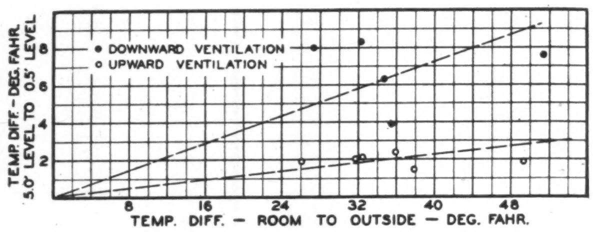

Fig. 6—Relation between temperature difference between the room and outside air and the temperature gradient, expressed in degrees difference, between the 5.0-ft level and the 0.5-ft level

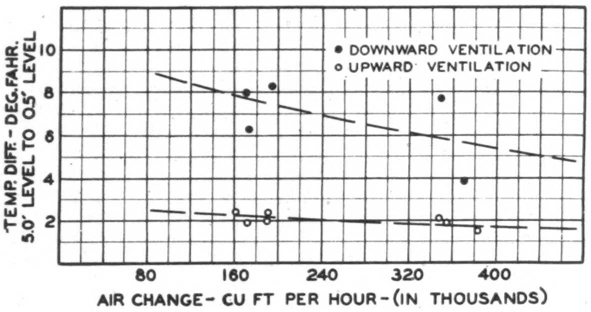

Fig. 7—Relation between air change and temperature gradient, expressed in degrees difference, between the 5.0-ft level and the 0.5-ft level

2. A lower rate of air change and a smaller heating load are required with upward than with downward ventilation.

3. Upward ventilation results in more uniform temperatures throughout the occupied portion of a building, a condition particularly desirable in a garage where men work close to the floor.

4. The study indicates that in the average case upward ventilation results in a lower concentration of carbon monoxide in the occupied portion of a garage than is had with complete mixing of the exhaust gases and the air supplied. However, the variations in concentration from point to point, together with the possible failure of the advantages of upward ventilation to accrue, suggest the basing of garage ventilation on complete mixing and an air change sufficient to dilute the exhaust gases to the allowable concentration of carbon monoxide.

5. The rate of carbon monoxide production by an idling car is shown to vary from 25 to 50 cfh, with an average rate of 35 cfh. This is in agreement with earlier Laboratory studies and the findings of the United States Bureau of Mines.

6. Accepting an average rate of carbon monoxide production of 35 cfh per idling car, an air change of 350,000 cfh per idling car is required to keep the carbon monoxide concentration down to one part in 10,000 parts of air.

A. S. A. Approves N. F. P. A. Code

A comprehensive code covering the installation, maintenance and use in buildings of piping and fittings for city gas has been approved by the *American Standards Association* as American Recommended Practice, following its submittal by the *National Fire Protection Association*. The code covers gas installations in buildings from the entry of the lines to the connections to appliances and includes provisions to make certain that gas-burning appliances shall be installed only where there are proper ventilating facilities.

The *National Fire Protection Association* has been designated sponsor for the project under the procedure of the *A. S. A.* and future revisions of the code will be handled by a technical committee.

A Pipe Sizer for Determining the Sizes of Pipes and of Restricting Orifices in a Hot-Water Heating System[*]

By **L. A. Cherry**[†] *(MEMBER)*
Buffalo, N. Y.

RECENTLY there has been a noticeable increase in the use of hot water heating systems, especially in large buildings. The advantages of this kind of a system, where room temperatures are easily regulated by changing the temperature of the water, have always made it a popular type, particularly in residences. The simplicity is such that expert care is not required.

Not until the last few years, however, has there been sufficient information available regarding the flow of hot water in pipes to enable the designer to proceed intelligently, and he has been forced to use rules-of-thumb rather than rational formulas. The research work done by Prof. F. E. Giesecke and associates at the Texas Engineering Experiment Station, of the Agricultural and Mechanical College of Texas, in cooperation with the A. S. H. V. E. Research Laboratory, has provided this information, so that now such systems may be laid out scientifically.

The purpose of the design of the Pipe Sizer, which will be described, was to take this available information, including that regarding friction through orifices, and place it in such form as to make it readily usable with the least amount of labor.

It is not necessary at the present time to discuss the general principle of operation of a hot water system, since there is no change proposed here in the method of calculation; but only a simplification of the means by which the available pressure heads may be balanced by friction heads so as to produce even circulation throughout the system.

Sources of Data

In the A. S. H. V. E. GUIDE of 1925-26 there are two logarithmic charts (See Figs. 33 and 34, pp. 80 and 81) showing Friction Heads in Milinches per Foot of Pipe and per Elbow respectively. In each case the heat conveyed per hour is in thousands of Btu, with a difference in temperature of the water in the flow and return lines at 20 F.

In the A. S. H. V. E. GUIDE, 1933 (Table 5, p. 98) is given the Friction Heads (in Milinches) of Central Circular Diaphragm Orifices in Unions for various sizes of orifices in pipes from ¾ in. to 2 in. inclusive. In this table the velocity is given in inches per second.

The logarithmic charts from which this table was prepared, together with a table showing orifice friction in 2½ in. pipe, have been furnished by W. H. Badgett, of the Texas Engineering Experiment Station.

Features Desired

In order to produce a device having as wide a scope as possible it was felt that the following points must be considered:

1. Some arrangement so that temperature differences other than 20 F could be used. (The Pipe Sizer has been arranged so that this difference, or temperature drop, may be taken at any value from 5 F to 30 F inclusive.)
2. Make the design such that the load carried by a pipe may be considered either in thousands of Btu per hour or equivalent square feet; so that the user may employ whichever unit is most convenient for him.
3. Instead of reading *unit* frictions in pipe and fittings, provide a means so that the *total* friction may be read without the necessity of multiplying the unit friction by the number of units.
4. Incorporate the information regarding friction heads in orifices in such a way that it may be easily applied, and without the necessity of calculating the velocity.

Description of Device

As will be noted in Fig. 1, there are five parts to the device which was designed: (1) Body, (2) Disk, (3) Pipe Sector, (4) Fitting Sector, and (5) Orifice Sector.

1. *Body:* At the bottom there are two scales from 5 to 30, both showing Temperature Drop Through Radiator (F); at the left a scale from 1 to 100 showing Length of Pipe (feet); at the right a scale from 1 to 100, showing Number of Equivalent Elbows; and at the top an arrow marked Pipe Size. In the upper right corner is also a convenient Table of Equivalent Elbows.
2. *Disk:* Along the lower edge is a scale from 1 to 10,000, showing Load Carried By Pipe, expressed either in Thousands of Btu or Equivalent Sq Ft, whichever the user finds more convenient. If the load is to be considered in thousands of Btu, the scale opposite the bottom

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[*] Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Hotel Statler, Detroit, Mich., June, 1933.

[†] Mechanical Engineer, Industrial Planning Corp.

left scale on the body is used; and if in equivalent square feet, that opposite the bottom right scale is used.

On the left side of the disk are Curves For Pipe sizes from ½ in. to 6 in.; on the right side are corresponding Curves For Fittings. The use of these is described in the following paragraphs 3 and 4.

Along the top edge of the disk is a scale from 50 to 100,000, showing Friction Head In Orifice in milinches and its use is described in paragraph 5.

3. *Pipe Sector:* This sector, on the left side of Pipe Sizer, and projecting over the disk, carries an arrow marked Length of Pipe, which is to be set opposite Length of Pipe In Feet on body. Along its upper edge is a scale showing Friction Head in Pipe in milinches; readings are taken where Curves For Pipe on disk intersect this edge.
4. *Fitting Sector:* This sector, on the right side of the Pipe Sizer, is similar to that on the left, and similarly used. The readings show Friction Head In Fittings in milinches.
5. *Orifice Sector:* This sector, which extends under the disk, carries on its right edge a scale of pipe sizes from ¾ in. to 2½ in., which is to be set opposite the arrow of Pipe Size on body. A set of curves showing Orifice Diameter (inches), from 0.3 to 1.6, are on the face of this sector. With the pipe size used set opposite the arrow of Pipe Size on body, opposite the Friction Head in Orifice to be produced (shown at top of disk), read the Orifice Diameter to be used in that size of pipe.

Example

If 50 sq ft of hot water radiation is carried by a 1 in. pipe 8 ft long with 10 equivalent elbows and the temperature drop of the water in passing through the radiator is 20 F, what is the friction head produced? If the pressure head available is 510 mil in., what size orifice must be inserted in the 1 in. pipe to use up the remaining head?

Solution (See Fig. 1). Set 50 sq ft (on the lower edge of disk) opposite 20 F drop (on bottom right scale on body); set arrow on pipe sector at left opposite 8 (length of pipe in feet); set arrow on fitting sector at right opposite 10 (equivalent elbows); then along upper edge of pipe sector read where curve for 1 in. pipe intersects, 55 mil in. and along upper edge of fitting sector read where curve for 1 in. fitting intersects, 140 mil in.; total 195 mil in. friction.

With a pressure head of 510 mil in. and a friction head of 195 mil in. there is left 315 mil in. to be produced by an orifice. Leaving disk in same position (with 50 sq ft opposite 20 F drop), on orifice sector set 1 in. (diameter of pipe) opposite pipe size arrow on body; then opposite 315 mil in. friction (on upper edge of disk) read 0.54 in. (diameter of orifice).

In this example the load was expressed in sq ft. If preferred, thousands of Btu may be used. The equivalent of 50 sq ft (at 150 Btu per sq ft per hr) is 7.5 thousands Btu. Then set 7.5 (on the lower edge of disk) opposite 20 F drop (on bottom left scale on body), and proceed as before. *Note that this is the same setting of disk as before.*

It is of course possible to provide the necessary friction by a choice of pipe sizes, and not use any orifice. If a certain size of pipe produces too much friction, and the next size too little, a portion of the pipe may be chosen of one size, and the remainder of the other, an thereby make the total friction equal the value desired.

The same example will illustrate the effect of differen pipe sizes. To determine how much of each size would be necessary to produce a friction head to balance th 550 mil in. of pressure head, note the following tabulation:

LENGTH OF PIPE	NO. OF EQUIV. ELLS	SIZE OF PIPE	FRICTION HEAD		
			PIPE	FITTINGS	TOTAL
8	10	1 in.	55	140	195 (1 in., too large)
8	10	¾ in.	200	400	600 (¾ in., too small)

By trying a portion of this as 1 in., and the remainder as ¾ in., it is found that:

LENGTH OF PIPE	NO. OF EQUIV. ELLS	SIZE OF PIPE	FRICTION HEAD		
			PIPE	FITTINGS	TOTAL
2	2	1 in.	14	25	39
6	8	¾ in.	150	320	470
8	10				509 (satisfactory)

Where the friction head to be produced is about the average of the friction of a pipe which is too large and the next size which is too small, one size may be used as the supply, and the other as the return. In general, however, it will be found easier to figure the orifice sizes.

With a given load on a certain size pipe, only one setting of the disk is required to determine friction of pipe, fittings, and orifice.

It is not necessary at any time to calculate the velocity of water.

Method Pursued in Design

Since the water carried by each section of pipe varies directly as the heating load and inversely as the temperature drop through the radiator, these two factors may be laid out logarithmically, the temperature drop through the radiator being placed on the Body of the Pipe Sizer at the bottom and the load along the lower edge of the Disk. The graduations for temperature drop are laid off twice: *first,* opposite the load in thousands of Btu; *second,* opposite the load in square feet, assuming the customary heat emission of 150 Btu per sq ft per hour.

The charts shown in THE GUIDE, 1925-26 (pp. 80 and 81) are similar, except that on page 81 the slope of all the lines is the same and has a value of 2, showing that the friction in fittings varies as the square of the velocity. These lines when placed on the Disk become a series of curves of exactly the same shape, the only change being that from rectangular to polar coordinates. On page 80 the lines for pipe sizes have a gradually increasing slope from the larger to the smaller sizes. When these lines are placed on the Disk, using polar coordinates, they become a series of similar curves, but somewhat fan-shaped.

The Pipe Sector and Fitting Sector, each overlapping the disk, are provided with logarithmic graduations; so

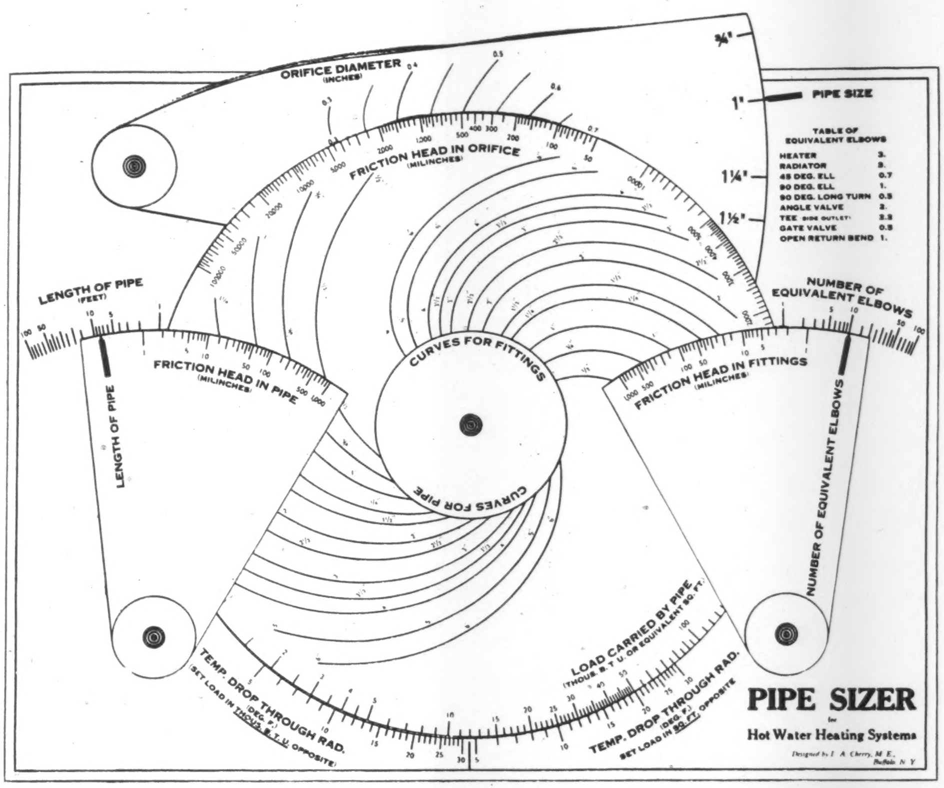

ORIFICE DIAMETER (INCHES)
FRICTION HEAD IN ORIFICE (MILINCHES)
¾"
1"
PIPE SIZE
1¼"
1½"
TABLE OF EQUIVALENT ELBOWS
HEATER 3.
RADIATOR 3.
45 DEG. ELL 0.7
90 DEG. ELL 1.
90 DEG. LONG TURN 0.5
ANGLE VALVE 2.
TEE (SIDE OUTLET) 2.2
GATE VALVE 0.5
OPEN RETURN BEND 1.
LENGTH OF PIPE (FEET)
NUMBER OF EQUIVALENT ELBOWS
FRICTION HEAD IN PIPE (MILINCHES)
FRICTION HEAD IN FITTINGS (MILINCHES)
CURVES FOR FITTINGS
CURVES FOR PIPE
LENGTH OF PIPE
NUMBER OF EQUIVALENT ELBOWS
LOAD CARRIED BY PIPE (THOUS. B. T. U. OR EQUIVALENT SQ. FT.)
TEMP. DROP THROUGH RAD. (DEG. F.) SET LOAD IN THOUS. B. T. U. OPPOSITE
TEMP. DROP THROUGH RAD. (DEG. F.) SET LOAD IN SQ. FT. OPPOSITE
PIPE SIZER
for
Hot Water Heating Systems
Designed by J. A. Cherry, M. E., Buffalo N. Y.

Fig. 1—Pipe Sizer, showing setting to solve problem given

that when the arrow on the sector is placed opposite the number of units, the intersection of the curves of pipe or fitting diameters with the edge of the sector give the total friction for that number of units directly.

In devising a method of showing the friction heads in orifices, it was necessary to determine not only how that friction varied with the load, but also, if possible, to see what relation existed between the friction in various orifice diameters in each of the various sizes of pipe. From an inspection of the charts for orifice frictions it could readily be seen that the friction varied in each case as the square of the velocity, all of the lines on all charts being parallel and having a slope of 2. It was not immediately apparent, however, just what the relationship was between the friction in various sized orifices in any size of pipe. The figures taken from the charts were plotted in a number of ways, the most illuminating of which is that shown in Fig. 2, which is semi-logarithmic, the abscissae being logarithmic and the ordinates arithmetic. This shows the loss of head in mil inches, when handling a load of 1000 lb of water per hour, passing through orifices whose diameters are of varying ratios to the diameter of the pipe. The investigations covered a range of ratios of diameter of orifice to diameter of pipe from ⅓ to ⅔, values beyond these figures not being consistent.

The general appearance of the lines on the chart in Fig. 2 suggested the making of Fig. 3. This chart is also semi-logarithmic, but instead of considering the same load in pounds of water per hour for all sizes of pipe, a constant velocity of 4 in. per second was taken. In this case all of the points fell very close to each other along a single straight line. This simplified the design of the computer, as it showed that for a certain ratio of diameter of orifice to diameter of pipe, and with a certain velocity, the friction was practically the same, irrespective of the pipe size.

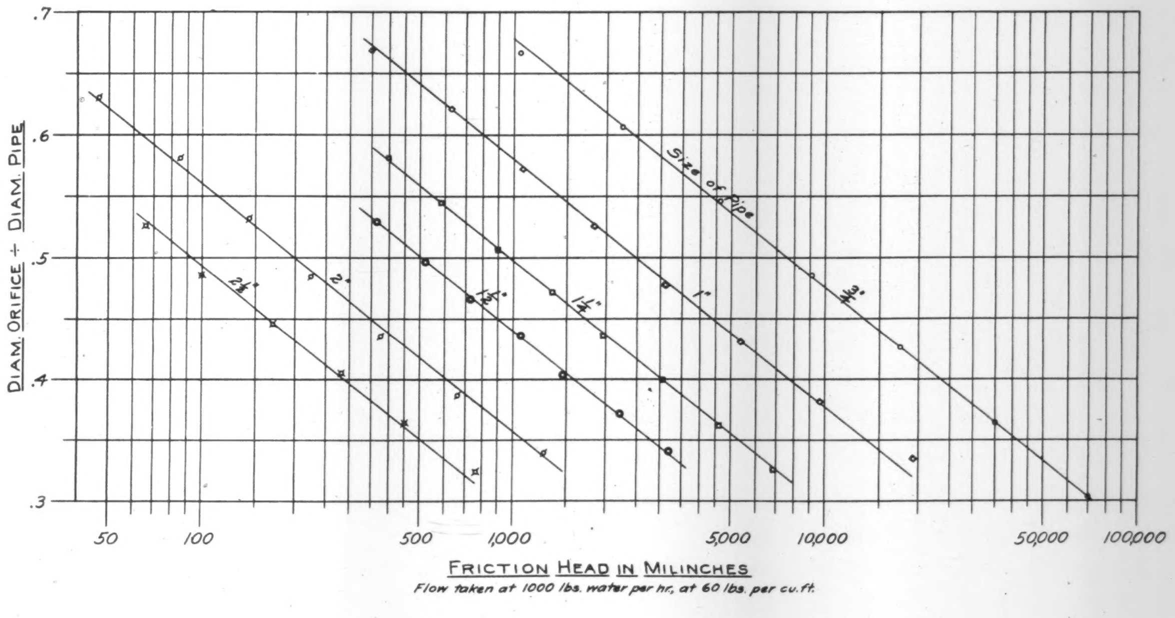
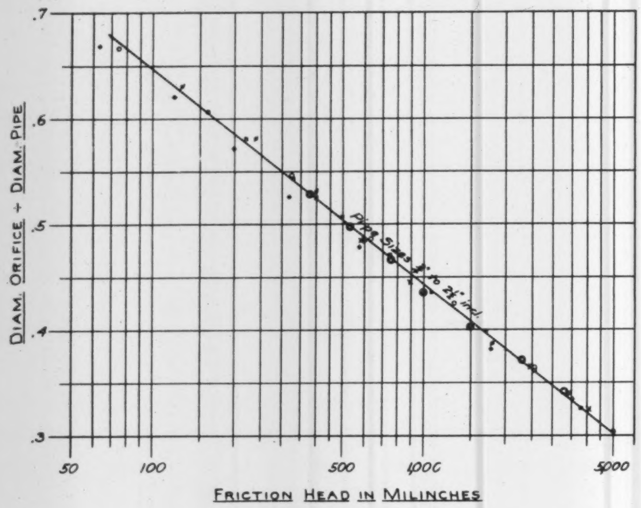


Fig. 2—Friction through orifices in various sizes of pipe

Since the friction heads in the orifices vary as the square of the velocity, and since the velocity is determined by the load carried by the pipe and the temperature drop through the radiator; consequently, if a fixed weight of water per cubic foot is assumed (which may be done without appreciable error for this part of the calculation), the friction head may then be laid off logarithmically along the upper edge of the Disk, using a scale one-half as large as that for loads on pipe and temperature drop. Then on the right edge of the Orifice Sector pipe sizes from ¾ in to 2½ in. inclusive are laid off, to any convenient scale. These are used in the determination of orifice sizes. The curves on this sector showing orifice diameter are obtained from the straight line in Fig. 3.



Flow taken at 4" per sec.

Fig. 3—Friction through orifices in various sizes of pipe

Calculation of Two-Pipe Upfeed Direct Return Gravity System

The calculation sheet (Fig. 4) shows a complete piping plan, with boiler, pipe, and radiators, and it is proposed that the pipe sizes be chosen so that the system will operate with a temperature drop of 25 F (190 F to 165 F). The calculations for the system are given completely on the sheet, in a form arranged for this purpose. (Obviously the item letters and guide lines are not used in actual practice, but only to describe the method of procedure.)

From the Chart of Pressure Heads (Fig. 5) it will be noticed that the dotted line shows that with an initial temperature of 190 F and a final temperature of 165 F, a head of 108 mil in. per ft of height will be produced. From the building or plans it is found that the height from the middle of the boiler (between the grate and top) to the middle of the first floor radiators is 5 ft; to second floor radiators, 15 ft; and to third floor radiators, 24 ft. The resulting pressure heads are as indicated in the upper corner of the sheet, Fig. 4.

Calculation of Mains

The main to be considered first is the one supplying the least favored radiator, which in this case is the 80 sq ft radiator at the end of the longer main. This radiator is the least favored, because it has the smallest pressure head (being on the first floor) and the greatest friction head (being at the end of the line). Starting at the boiler and in order along this main list under mains, the quantities of radiation expressed in square feet (or in thousands Btu, if preferred) as shown in Column *A*. For demonstration sq ft has been chosen. The third figure in this column (Item *a*) is the branch main, carrying a total of 320 sq ft.

Starting at the bottom of Column *B* and working upward, following the guide line, the continued totals are recorded which give the load carried by each section of the main. The total of all radiation is 910 sq ft (the top item in Column *B*).

In Column *C* enter the length of pipe in each section of the mains (including both supply and return as one item) opposite the load for that section. From the plan, including vertical pipes also (which are not shown) it is found that the length of the supply main from the boiler to *A* is 10 ft, and of the return to *B* is 16 ft; adding these the sum 26 is the length of pipe carrying 910 sq ft. If in the supply main, the distance from *A* to *C* is 5 ft, and in the return from *B* to *D* is the same, enter 10 as the length carrying 860 sq ft, and so on for the other lines. For the pipe carrying 80 sq ft (the last radiator) include the length of the radiator runouts and the stubs up to the middle of the radiator, as these are parts of this circuit.

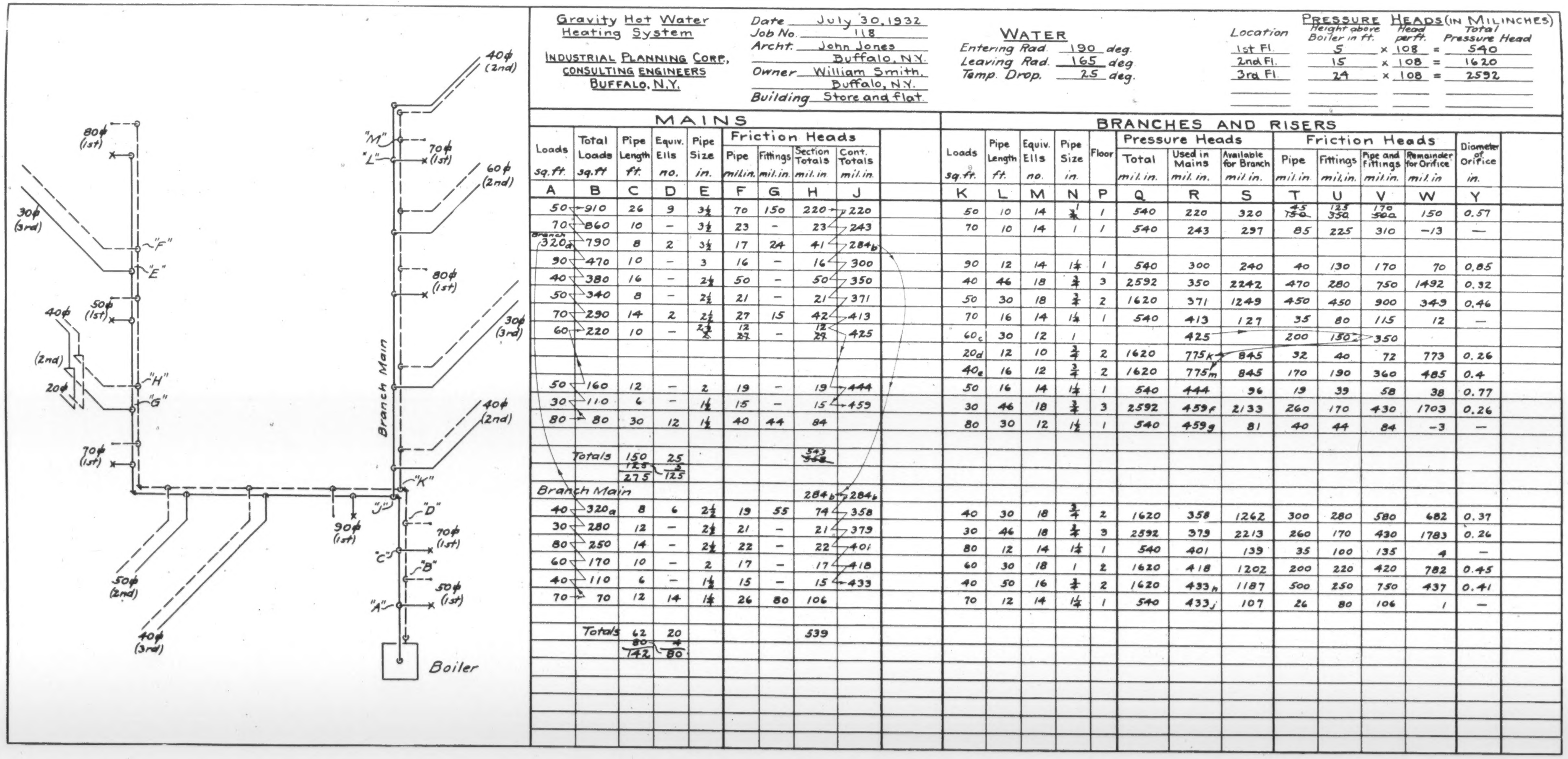
In Column *D* enter the total equivalent ells in each section of main, as given in table on the Pipe Sizer. In the first section of this system there are 6 ells and the boiler (3 equivalent ells); so that 9 is the number of equivalent ells in this section. Similarly enter the equivalent ells for the remaining sections. In the last section, carrying 80 sq ft, include the equivalent of the radiator valve (2 ells) and of the radiator itself (3 ells), which with the ells in the piping makes a total of 12.

The pipe sizes of the main will now be selected approximately, and then corrected where necessary. The total length of this circuit is 150 ft (Column *C*), with 25 equivalent ells (Column *D*). For a rough estimate, assume that an elbow is equivalent to twice as many feet of pipe as the diameter of the pipe in inches: *i.e.*, a 1 in. ell equivalent to 2 ft of 1 in. pipe; a 2 in. ell equivalent to 4 ft of 2 in. pipe; and so on. Assuming that the average size of this main is 2½ in., the equivalent length of pipe per ell is 5 ft, or 125 ft for the 25 ells, making the total equivalent length 275 ft, as shown. The pressure head to produce the flow to the first floor is 540 mil in., so the total friction head must not exceed this figure, or 540 ÷ 275 = 2 mil in. per ft. of length (approximately).

Now use the Pipe Sizer for calculations. Set 910 sq ft (the total load) on disk opposite 25 F drop on body; set arrow on pipe sector opposite 1 on body, since the drop is in mil inches per foot of length; then opposite 2 mil inches on edge of sector, note that the nearest curve is that for 3½ in. pipe. In Column *E* enter 3½ in. as a trial size for this pipe. Continue down this column, successively setting the various total loads opposite 25 F drop, and choosing the size of pipe whose curve is nearest to the friction of 2 mil inches.

With these trial sizes (Column *E*), and with lengths of

Fig. 4—Calculation sheet for a two-pipe upfeed gravity hot water heating system



Gravity Hot Water Heating System

INDUSTRIAL PLANNING CORP.
CONSULTING ENGINEERS
BUFFALO, N.Y.

Date July 30, 1932
Job No. 118
Archt. John Jones
Buffalo, N.Y.
Owner William Smith,
Buffalo, N.Y.
Building Store and flat.

WATER
Entering Rad. 190 deg.
Leaving Rad. 165 deg
Temp. Drop. 25 deg.

PRESSURE HEADS (IN MILINCHES)			
Location	Height above Boiler in ft.	Head per ft.	Total Pressure Head
1st Fl.	5	× 108	= 540
2nd Fl.	15	× 108	= 1620
3rd Fl.	24	× 108	= 2592

MAINS										BRANCHES AND RISERS													
Loads	Total Loads	Pipe Length	Equiv. Ells	Pipe Size	Friction Heads					Loads	Pipe Length	Equiv. Ells	Pipe Size	Floor	Pressure Heads			Friction Heads				Diameter of Orifice	
					Pipe	Fittings	Section Totals	Cont. Totals							Total	Used in Mains	Available for Branch	Pipe	Fittings	Pipe and Fittings	Remainder for Orifice		
sq.ft.	sq.ft	ft.	no.	in.	mil.in.	mil.in.	mil.in	mil.in.		sq.ft.	ft.	no.	in.		mil.in.	mil. in.	mil.in.	mil.in	mil.in.	mil.in.	mil.in	in.	
A	B	C	D	E	F	G	H	J		K	L	M	N	P	Q	R	S	T	U	V	W	Y	
50	910	26	9	3½	70	150	220	220		50	10	14	~~¾~~ 1	1	540	220	320	45 ~~75a~~	123 ~~35a~~	170 ~~50a~~	150	0.57	
70	860	10	–	3½	23	–	23	243		70	10	14	1	1	540	243	297	85	225	310	−13	—	
Branch 320a	790	8	2	3½	17	24	41	284b															
90	470	10	–	3	16	–	16	300		90	12	14	1¼	1	540	300	240	40	130	170	70	0.85	
40	380	16	–	2½	50	–	50	350		40	46	18	¾	3	2592	350	2242	470	280	750	1492	0.32	
50	340	8	–	2½	21	–	21	371		50	30	18	¾	2	1620	371	1249	450	450	900	349	0.46	
70	290	14	2	2½	27	15	42	413		70	16	14	1¼	1	540	413	127	35	80	115	12	—	
60	220	10	–	2½ ~~2~~	12 ~~27~~	–	12 ~~27~~	425		60c	30	12	1			425		200	150	350			
										20d	12	10	¾	2	1620	775k	845	32	40	72	773	0.26	
										40e	16	12	¾	2	1620	775m	845	170	190	360	485	0.4	
50	160	12	–	2	19	–	19	444		50	16	14	1¼	1	540	444	96	19	39	58	38	0.77	
30	110	6	–	1½	15	–	15	459		30	46	18	¾	3	2592	459f	2133	260	170	430	1703	0.26	
80	80	30	12	1½	40	44	84			80	30	12	1½	1	540	459g	81	40	44	84	−3	—	
Totals		150 125 275	25 5 125				543 ~~558~~																
Branch Main							284b	284b															
40	320a	8	6	2½	19	55	74	358		40	30	18	¾	2	1620	358	1262	300	280	580	682	0.37	
30	280	12	–	2½	21	–	21	379		30	46	18	¾	3	2592	379	2213	260	170	430	1783	0.26	
80	250	14	–	2½	22	–	22	401		80	12	14	1¼	1	540	401	139	35	100	135	4	—	
60	170	10	–	2	17	–	17	418		60	30	18	1	2	1620	418	1202	200	220	420	782	0.45	
40	110	6	–	1½	15	–	15	433		40	50	16	¾	2	1620	433h	1187	500	250	750	437	0.41	
70	70	12	14	1¼	26	80	106			70	12	14	1¼	1	540	433j	107	26	80	106	1	—	
Totals		62 80 142	20 4 80				539																

pipe and number of fittings in each section (Columns *C* and *D*), the actual friction head will now be determined, and then such changes made in pipe sizes as are necessary to make the friction head equal to the pressure head (See Fig. 6). Set 910 sq ft on disk opposite 25 F drop on body; set arrow on pipe sector opposite 26 (length of pipe) on body; set arrow on fitting sector opposite 9 (number of equivalent ells); then where curve for 3½ in. pipe on disk intersects edge of pipe sector, read 70 mil in. as the friction in that section of pipe (Column *F*); and where curve of 3½ in. fitting on disk intersects edge of fitting sector, read 150 mil in. as the friction due to the fittings in that section (Column *G*); and enter their total of 220 for that section (Column *H*). Continue for each load and size of pipe, using the respective lengths and number of fittings. Adding Column *H*, the total friction head is 558 mil in.; but since only 540 mil in. of pressure head is available, the friction must be reduced so as not to exceed this figure. This is effected by increasing the size of one or more sections of pipe. It makes no difference just where this is done, but since the reduction to be made is small, it can be easily done in a short length of pipe. Try increasing the pipe carrying 220 sq ft, from 2 in. to 2½ in.; then the friction of this section of pipe is reduced from 27 mil in. to 12 mil in., and the total from 558 mil in. to 543 mil in., which is satisfactory. (There are no fittings in this section.)

Now fill in Column *J* of the continued totals, by adding successively the section totals from Column *H*, as shown by guide lines. These give the total of the frictions in both supply and return mains from the boiler up to the branch connection to each radiator, and which will be used later.

In calculating the branch main (Item *a*) and its branches, the condition is somewhat different, as the least favored radiator on this line is not the last one, but is the last of those on the first floor, the 70 sq ft. The circuit to this least favored radiator includes the mains from *M* to the boiler and back to *L*, and the radiator branches from *L* to the 70 sq ft radiator and back to *M*.

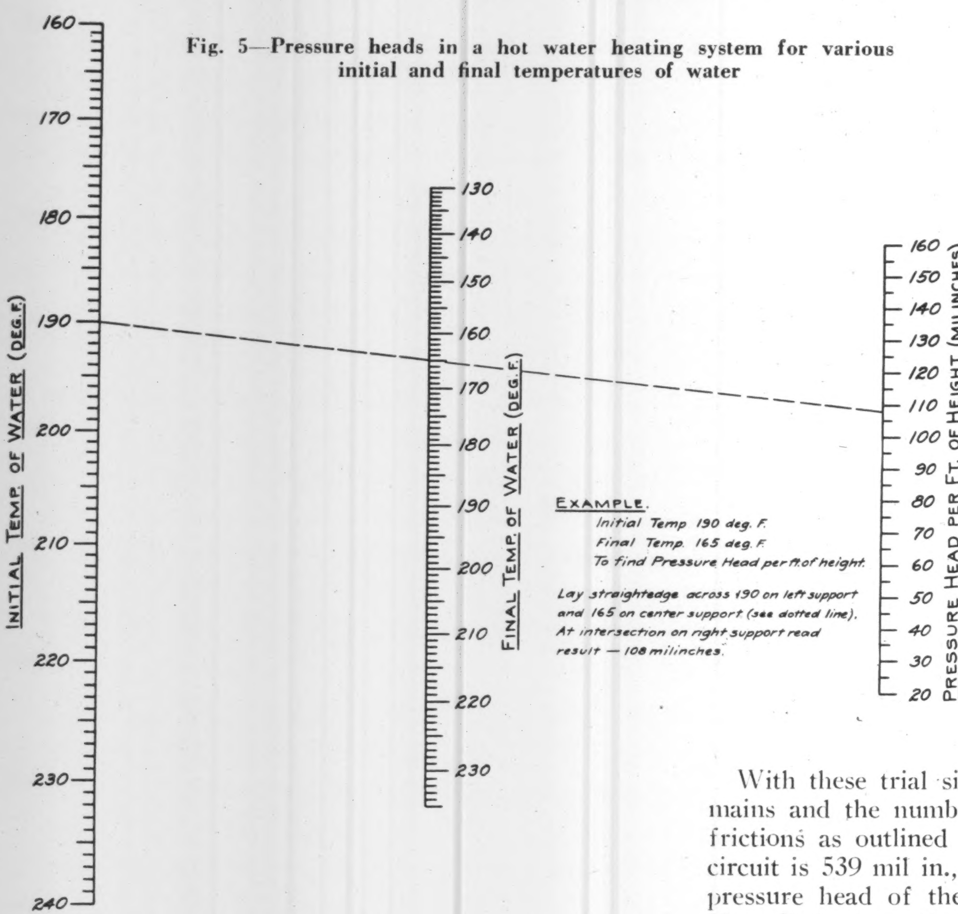


Fig. 5—Pressure heads in a hot water heating system for various initial and final temperatures of water

If the assumption had been made that the last radiator on the second floor was the least favored, the second floor head would have been considered as available for circulation. The result would have been smaller mains and a friction head in the complete circuit to the 70 sq ft radiator on the first floor, greater than the pressure head available for circulation. This 70 ft radiator would not function properly. Therefore it is necessary to use sizes which will be satisfactory for the first floor radiator, the least favored on this line.

In the same manner as before, fill in Columns *A, B, C* and *D*. The last two radiators are apparently reversed, but as the circuit to the 70 sq ft radiator is being considered as the least favored, the 40 sq ft radiator is reached first.

The total length of this circuit is 62 ft; assuming the average size of pipe to be 2 in. and each ell equivalent to about 4 ft of pipe, or 80 ft for the 20 ells, the total is 142 ft. The total pressure head for this first floor radiator is 540 mil in., of which 284 mil in. (Item *b*) is used in the main from *K* to the boiler and back to *J*, so that 256 mil in. is available for use in the portion from *J* to *L* to the 70 sq ft radiator to *M* to *K*. Since the equivalent length of this part is 142 ft, the drop is 256 ÷ 142 = 1.8 mil in. per foot of length (approximately).

Set 320 sq ft opposite 25 F drop on body; set arrow on pipe sector opposite 1 ft of length; opposite 1.8 mil in. on top of sector, note that the nearest curve is 2½ in. (Column *E*), the size of main for this section. Similarly obtain sizes of the remaining sections.

With these trial sizes, and the length of sections of mains and the number of equivalent ells, calculate the frictions as outlined before. The total friction in this circuit is 539 mil in., which is almost identical with the pressure head of the 540 mil in., and is satisfactory. Now fill in the column of continued totals (Column *J*.)

Calculations for Branches and Risers

Enter the individual loads in Column *K* as in Column *A*, except that the branch main (Item *a*) is omitted; Item *c* being the riser, and Items *d* and *e* the two radia-

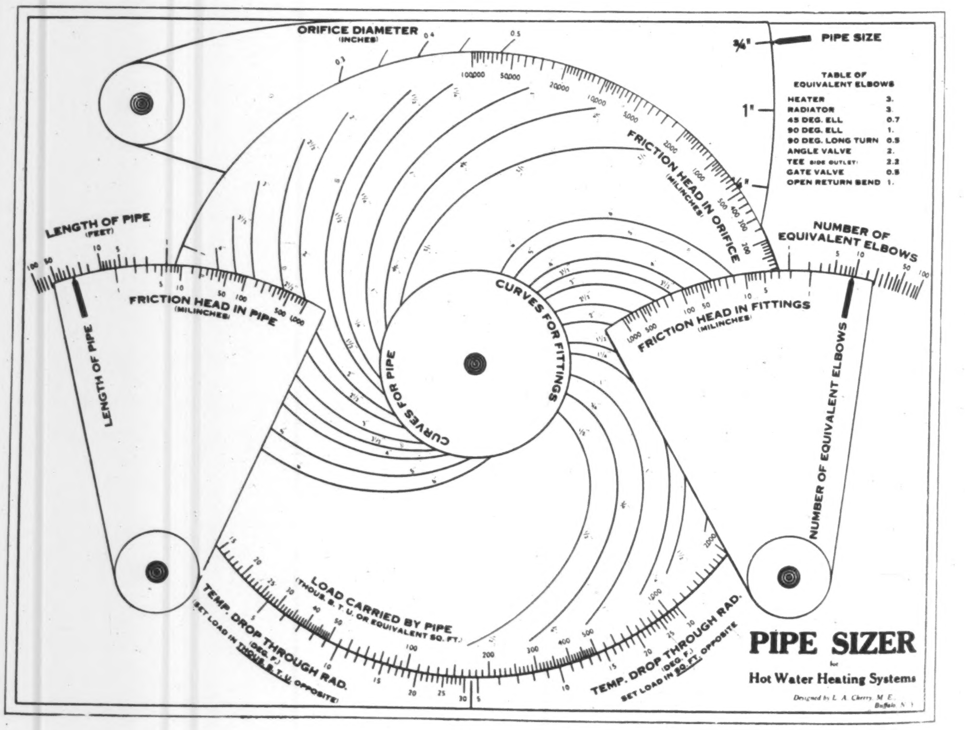

ORIFICE DIAMETER (INCHES)
FRICTION HEAD IN ORIFICE (MILINCHES)
¾"
1"
PIPE SIZE
TABLE OF EQUIVALENT ELBOWS
HEATER 3.
RADIATOR 3.
45 DEG. ELL 0.7
90 DEG. ELL 1.
90 DEG. LONG TURN 0.5
ANGLE VALVE 2.
TEE (SIDE OUTLET) 2.2
GATE VALVE 0.5
OPEN RETURN BEND 1.
NUMBER OF EQUIVALENT ELBOWS
LENGTH OF PIPE (FEET)
FRICTION HEAD IN PIPE (MILINCHES)
LENGTH OF PIPE
CURVES FOR PIPE
CURVES FOR FITTINGS
FRICTION HEAD IN FITTINGS (MILINCHES)
NUMBER OF EQUIVALENT ELBOWS
LOAD CARRIED BY PIPE (THOUS. B. T. U. OR EQUIVALENT SQ. FT.)
TEMP. DROP THROUGH RAD. (DEG. F.)
SET LOAD IN THOUS. B. T. U. OPPOSITE
TEMP. DROP THROUGH RAD. (DEG. F.)
SET LOAD IN SQ. FT. OPPOSITE
PIPE SIZER
for
Hot Water Heating Systems
Designed by L. A. Cherry, M. E., Buffalo, N. Y.

Fig. 6—Pipe Sizer, showing setting to determine friction in first section of main (Fig. 4)

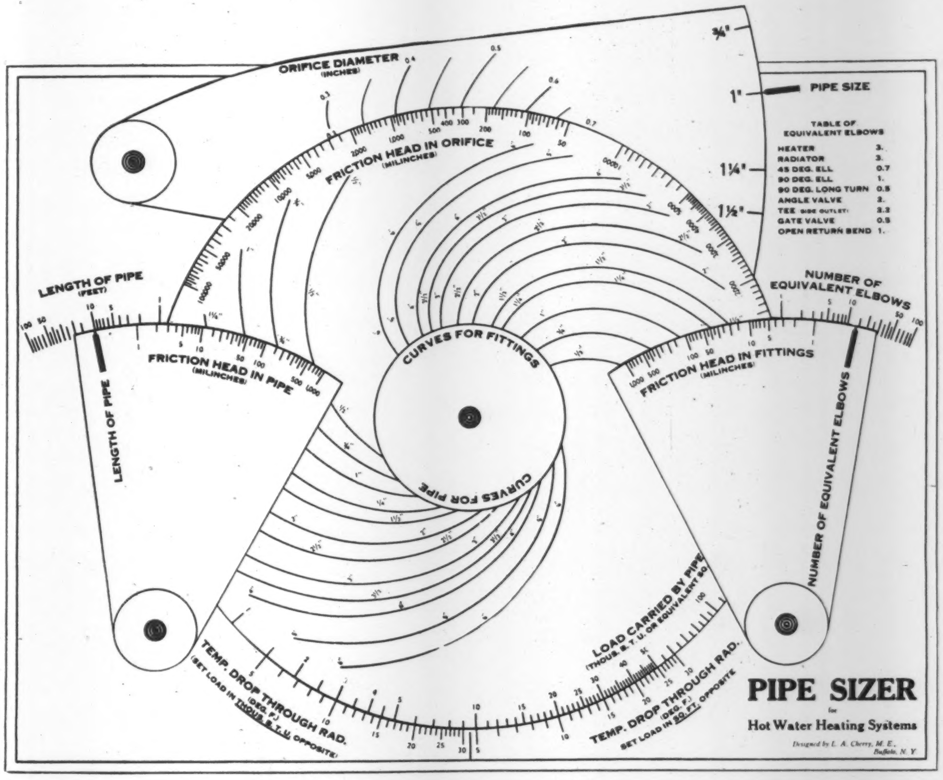

ORIFICE DIAMETER (INCHES)
FRICTION HEAD IN ORIFICE (MILINCHES)
LENGTH OF PIPE (FEET)
FRICTION HEAD IN PIPE (MILINCHES)
CURVES FOR FITTINGS
CURVES FOR PIPE
FRICTION HEAD IN FITTINGS (MILINCHES)
NUMBER OF EQUIVALENT ELBOWS
LOAD CARRIED BY PIPE (THOUS. B.T.U. OR EQUIVALENT SQ. FT.)
TEMP. DROP THROUGH RAD. (DEG. F.) SET LOAD IN THOUS. B.T.U. OPPOSITE
TEMP. DROP THROUGH RAD. (DEG. F.) SET LOAD IN SQ. FT. OPPOSITE
¾"
1"
1¼"
1½"
PIPE SIZE
TABLE OF EQUIVALENT ELBOWS
HEATER 3.
RADIATOR 3.
45 DEG. ELL 0.7
90 DEG. ELL 1.
90 DEG. LONG TURN 0.5
ANGLE VALVE 2.
TEE (SIDE OUTLET) 2.2
GATE VALVE 0.5
OPEN RETURN BEND 1.
PIPE SIZER
for
Hot Water Heating Systems
Designed by L. A. Cherry, M. E., Buffalo, N. Y.

Fig. 7—Pipe Sizer, showing setting to determine size of branches and orifice for 50 sq ft radiator nearest boiler (Fig. 4)

tors on this riser. Fill in Columns *L* and *M* with the lengths of pipe and equivalent ells, as given on plans, using values of equivalents from table on the Pipe Sizer. Fill in Columns *P* and *Q*, showing the floor on which each radiator is located, and the corresponding pressure head, taken from upper part of calculation sheet. Column *R* is the same as Column *J*, *except* where more than one radiator is on a branch; also note that Items *f* and *g* (Column *R*) are alike, similarly Items *h* and *j* (Column *R*).

In the first line subtract 220 (Column *R*) from 540 (Column *Q*), and enter the difference 320 (Column *S*). This is the pressure head remaining to produce circulation to the 50 sq ft radiator, and should be used in friction in this branch. Try assuming the branch to this radiator at ¾ in. (Column *N*). (See Fig. 7.)

Set the load of 50 sq ft on disk opposite 25 F drop, arrow on pipe sector opposite 10 (Column *L*), and arrow on fitting sector opposite 14 (Column *M*), then read at the intersection of ¾ in. pipe curve the value of 150 (Column *T*), and at the intersection of ¾ in. fitting curve 350 (Column *U*), making the total 500 (Column *V*). The friction head of 500 is greater than the available pressure head of 320 (Column *S*), and is not satisfactory. Without changing setting of Pipe Sizer, read for 1 in. a pipe friction of 45 mil in., and a fitting friction of 125, total 170, which is less than the 320 mil in. available. Without moving disk on Pipe Sizer, set 1 in. on orifice sector opposite arrow, and opposite friction head of 150 (Column *W*) on top of disk read diameter of orifice of 0.57 in. (Column *Y*). Similarly calculate the items for the remaining radiators, except the two on one riser, using pipe size just large enough so that the friction of pipe and fittings will be less than the pressure head, and supplying remaining friction by an orifice.

In figuring the sizes of pipes for the two radiators on one riser, the simplest method is partly by trial. Assume riser to be 1 in. (Column *N*) and calculate 200 (Column *T*), 150 (Column *U*), and 350 (Column *V*), this being the total drop in the risers alone. Add this figure to the 425 mil in. (Columns *J* and *R*) which is the drop in the mains from *H* to the boiler and back to *G*, and the total is 775 mil in., which is now put down as Items *k* and *m* in Column *R*. Subtract 775 (Column *R*) from 1620 (Column *Q*) and enter the difference 845 (Column *S*), which is available for the friction in each of these two radiators and its branches. Try the pipe size for the 20 sq ft radiator at ¾ in. and calculate friction and orifice.

This pipe size might have been taken at ½ in., in which case the pipe friction would have been 130 mil in.; fitting friction 130 mil in.; and the total, 260 mil in., which is well below the available pressure head of 845 mil in. (Column *S*). But as there are no data available at present on orifices in ½ in. pipe, ¾ in. is used. Calculate the size of pipe for the 40 sq ft radiator on this riser in a similar manner, as shown. The remaining items on the calculation sheet require no explanation.

Fig. 4 then gives all of the information necessary for the completion of the plans, and shows a system completely *balanced*. All pipe sizes have been calculated, and the sizes of all orifices, where necessary, are given.

This example has been described in rather minute detail, so that the procedure might be thoroughly understood. The actual calculation is accomplished in much less time than is necessary to explain the method.

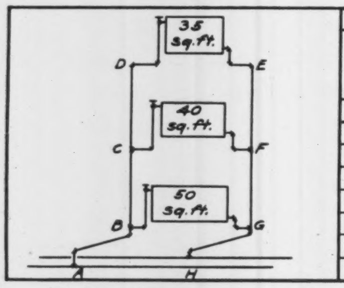
It is not imperative that pipe sizes be used in the main which will produce the same friction per foot of length. Arbitrary sizes may be used, if desired, and it is found advantageous oftentimes to use mains without reductions. In any case the same method of calculation should be used in balancing the friction head against the pressure head.

Calculation of a Typical Riser

Fig. 8 shows a typical riser with 50 sq ft on the first floor, 40 sq ft on the second, and 35 sq ft on the third. Assume that the heights above the boiler, and the temperature drop are the same as in the preceding example, to produce pressure heads of 540, 1620, and 2592 mil in. respectively; also assume that the friction in the mains up to the tees for this riser is 230 mil in.

The branch circuit to the 50 sq ft radiator on the first floor consists of two sections of pipe; the branch and riser (*A* to *B*, and *G* to *H*), carrying 125 sq ft and the radiator connection (*B* to radiator to *G*) carrying 50 sq ft. In the circuit to the 40 sq ft radiator on the second floor there are also the risers (*B* to *C*, and *F* to *G*), carrying 75 sq ft, and the radiator connections (*C* to radiator to *F*), carrying 40 sq ft. The circuit to the 35 sq ft radiator on the third floor has only one additional section, including risers and radiator connections (*C* to *D* to radiator to *E* to *F*).

Tabulate the items in Columns *K*, *L*, *M*, *P*, and *Q*. (The column headings in Fig. 8 are the same as in Fig. 4.) Items *a* and *b* in Columns *L* and *M* are the feet of pipe and number of ells in branch and riser to the first floor (*A* to *B*, and *G* to *H*). Items *c* and *d* are for connections to the first floor radiator (*B* to radiator to *G*). Items *e* and *f* are for risers from first to second floor (*B* to *C*, and *F* to *G*), and Items *g* and *h* are for connections to second floor radiator (*C* to radiator to *F*). Items *j* and *k* include risers from second to third floor, and radiator connections (*C* to *D* to radiator to *E* to *F*). Item *m* in Column *R* is 230 mil in. according to the conditions stated in the problem and Item *n* in Column *S* is 310, the difference between 540 (Column *Q*) and 230 (Column *R*).



BRANCHES AND RISERS												
					Pressure Heads			Friction Heads				
Loads sq. ft.	Pipe Length ft.	Equiv. Ells no.	Pipe Size in.	Floor	Total mil. in.	Used in Mains mil. in.	Available for Branch mil. in.	Pipe mil. in.	Fittings mil. in	Pipe and Fittings mil. in.	Remainder for Orifice mil. in.	Diameter of Orifice in.
K	L	M	N	P	Q	R	S	T	U	V	W	Y
125	16_a	8_b	1½		540	230_m	310_n	50	75	125		
50	6_c	12_d	1	1	540	355_p	185_q	28	100	128	57	0.66
75	10_e	$-_f$	1		1620	355_r	1265_s	100	—	100		
40	6_g	12_h	¾	2	1620	455_t	1165_u	60	190	250	915	0.35
35	29_j	10_k	¾	3	2592	455_v	2137_w	230	130	360	1777	0.29

Fig. 8—Calculation sheet for a typical riser

The size of branches to risers, and connections to the first floor radiator, must have a friction head that will approximate this available pressure head of 310 mil in. Try the branch size at 1½ in. and calculate pipe friction 50 (Column *T*), fitting friction 75 (Column *U*), or a total 125 (Column *V*). The friction head up to the tees (*i.e.*, *B* to boiler to *G*) for the first floor radiator is then found by adding 230 (Column *R*) and 125 (Column *V*) to make 355 (Item *p*), leaving 185 (Item *q*) to be used in friction in the connections to this radiator (*B* to radiator to *G*). Assume radiator connections to be 1 in. and calculate frictions and orifice size for the 50 sq ft first floor radiator in the usual manner. The orifice diameter is 0.66 in.

The friction head to tees *B* and *G* is 355 (Item *r*) and is the same as Item *p*. As the total pressure head for the second floor is 1620 mil in. the available pressure head is 1265 (Item *s*), the difference between the two. Then the friction from *B* to *C* to radiator to *F* to *G* must be such as to equal this available head. Try this section of riser at 1 in., and calculate frictions, totaling 100 (Column *V*). Then Item *t* is found by adding 355 and 100, or 455. Item *u* therefore is 1165. Taking this section of risers at ¾ in., calculate frictions and orifice size for the 40 sq ft second floor radiator. The orifice diameter is found to be 0.35 in.

Similarly Item *v* is 455, and Item *w* is 2137. A trial using ¾ in. for the pipe to this third floor radiator and calculating remaining items, gives the orifice for this radiator 0.29 in.

Chart of Pressure Heads

In order to facilitate the calculation of pressure heads, Fig. 5, already mentioned, was plotted. The formula for the pressure head is as follows:

$$h = \frac{a - b}{\frac{a + b}{2}} \times 12 \times 1000$$

where

h = Head (mil in.)

a = Weight of water at final temperature (lb per cu ft)

b = Weight of water at initial temperature (lb per cu ft)

This equation may be transformed so as to read

$$\frac{a}{b} = \frac{24000 + h}{24000 - h}$$

The design of this alinement chart presented no unusual difficulties, but a mathematical curiosity appeared. Since this chart is to perform a division, *a* and *b* are laid off logarithmically; however the resultant pressure head appears with graduations which are apparently arithmetic, though actually logarithmic. In the equation, *h* is always very small relative to 24,000, so that within the limits in question the value of this fraction is proportional to the logarithm of the value, consequently the graduations on this part of the chart are equally spaced.

Conclusion

The writer does not claim to have added in any way to the existing amount of information on this subject. The attempt has been made to take research data and arrange them in such a way that the labor involved in the calculation of a hot water heating system may be reduced to a minimum, and so encourage the use of a scientific method of calculation.

It will be apparent that the calculation of other types of systems may be facilitated, including one-pipe gravity, forced circulation, or combinations of the two.

It might be added that this device has been used not only to design a number of gravity hot water heating systems, but also to determine all changes to be made on some existing *trouble jobs* so that they functioned properly.

Local Chapter Reports

Illinois

May 8, 1933. The May meeting of the Illinois Chapter was held at the Hotel Sherman, Chicago, with an attendance of 54, when Pres. J. H. O'Brien called the gathering to order at 8:10 p.m. The minutes of the April meeting were read and approved.

Homer Linn was called upon to tell the members about the joint meeting of the Wisconsin, Minnesota and Illinois Chapters at La Crosse, Wis., April 25, and reported a most interesting all day program.

President O'Brien then read a communication from A. V. Hutchinson, Secretary of the Society, regarding the National Conference on Renewal of Home Building, to be held at the Congress Hotel, May 9 and 10. Another letter from Headquarters was also read, telling of plans for the Semi-Annual Meeting of the Society to be held in Detroit, June 22 24.

J. J. Aeberly introduced Bennett Chapple, Middletown, Ohio, whose subject was Tomorrow's Home. Mr. Chapple has been active in the development of the use of metal in low cost home construction, and was interested in the construction of the frameless steel house in Cleveland last year. In his talk, Mr. Chapple described in detail the design and construction of the $5,000 steel house with porcelain enameled siding now under construction at the Century of Progress. Points of particular interest to the heating and ventilating engineer were the speakers' references to insulation methods against heat and cold and the possibilities for panel heating and air conditioning applications.

Dr. E. V. Hill introduced the second speaker, A. R. Herske, who discussed Profits in the Contracting Business.

A lengthy discussion followed these two talks and both speakers were called upon to answer numerous questions, after which a vote of appreciation was tendered to them. Secy. J. J. Hayes states that the Chapter members were so pleased with the program that C. W. DeLand, chairman of the Meetings Committee, was given a special vote of thanks for providing such interesting speakers.

Kansas City

May 8, 1933. The Kansas City Chapter met for the regular May meeting at the Hotel Newbern at 6:00 o'clock and the routine business included the annual election of officers. The following members were unanimously elected to serve:

President—David Caleb.
Vice-President—D. D. Zink.
Secretary—C. A. Weiss.
Treasurer—L. A. Stephenson.
Board of Governors—B. F. Cook, Emil Haas, and W. A. Russell.

Following the election President Russell carried on, giving the Chapter a survey of the June meeting of the A. S. H. V. E. in Detroit and Engineers Week at the Century of Progress, Chicago.

Plans were tentatively made for a June social meeting of the Kansas City Chapter and a committee was appointed to make arrangements, consisting of J. M. Arthur, Benjamin Natkin, L. R. Chase and Kerker Campbell.

There were two speakers for the evening, both of local talent, thus winding up the educational program of the year. L. W. Millis presented a paper on the Principles of Combustion—(Stokers, Oil and Gas Burners) and by the aid of slides and illustrations from his own broad experience, he gave the Chapter a very enjoyable as well as instructive exposition of the subject.

Following the first speaker, Mr. Caleb gave a paper on Heating and Ventilating in Perspective, taking into consideration both the past and future. He touched on and coordinated the studies which have been made during the year by the Educational Committee and the local members who have presented papers and then outlined some of the problems, which should come under the Chapter's survey in its educational program during the coming year. Mr. Caleb enumerated many of the phases of heating, piping and air conditioning which seemed to need further development and requested the members to study the list and make suggestions which might be incorporated in next year's program. It was felt that the educational feature had been so successful that it should be carried on and enlarged.

At this meeting it was learned that President Russell had been holding out on the members and that he had been First Vice-President of the Presidents' Roundtable, an organization consisting of the presidents of the leading civic organizations in the city. The Chapter was happy to have one of their number receive the honor of such a position.

The report of D. D. Zink stated that in June a social meeting would be held for the wives, families and friends of the Chapter.

Massachusetts

May 8, 1933. Thirty members of the Massachusetts Chapter assembled for dinner at Durgin and Park's restaurant on Haywood Place in Boston at 6:30 p. m. Pres. F. R. Ellis, who has been convalescing from a recent operation, presided and, after dinner, called upon Secy. Leslie Clough to report on the ballot for two members to serve on the Board of Governors for three years.

L. A. Brissette and E. Q. Cole were unanimously elected and the Board of Governors now consists of: F. R. Ellis and C. R. Swaney (*one year*); E. W. Berchtold and L. D. Cushman (*two years*); and L. A. Brissette and E. Q. Cole (*three years*).

Mr. Cole, of the Papers and Meetings Committee, gave a brief outline of the subject to be discussed at the meeting by several of the Chapter members and then introduced J. F. Tuttle, R. S. Twitchell, Mr. Brightman, and T. F. McCoy.

Each of the four speakers provided reliable and interesting data and gave a comprehensive description with chart illustrations of his ideas and practices regarding the control of steam to a heating system by the use of orifices, zone control and pneumatic or other regulation.

Following the time allotted for the speakers, a general discussion of the subject matter was enjoyed by the members.

The new Board of Governors will elect officers to serve the Chapter for the coming year.

This was the last regular meeting of the 1932-33 season during which interest in membership attendance and social pleasure gained impetus as the season advanced.

Michigan

May 10, 1933. About 50 members and guests enjoyed the golf tournament at Meadowbrook Country Club and, following dinner served in the Club House, Pres. L. L. McConachie called the meeting to order. The minutes of the previous meeting were read and approved and the treasurer's report was accepted.

Golf prizes were awarded to the following: Messrs. Stevens, Connell, Arnoldy, Milward, Kilner, Emrich, Gates, Sheley, Glanz, Marzoff, Anderson, Walsh, Brown, Wallich, Rowe, Winans, Dubry, Tuttle and Mattingly. Prizes were also awarded to the following baseball players: Messrs. Fuller, Clark and Lantz.

E. H. Clark explained the program for the Semi Annual Meeting of the Society and the method of distributing tickets for entertainment events. President McConachie called for reports of the various committees of the Committee on Arrangements.

The secretary, G. D. Winans, read the report of the Nominating Committee and it was regularly moved and seconded that the secretary be instructed to cast a unanimous vote for the officers presented as follows:

President—H. E. Paetz.
Vice-President—G. D. Winans.
Secretary—Tom Brown.
Treasurer—R. K. Milward.

The members of the Board of Governors were voted for by ballot and the tellers, Messrs. E. E. Dubry, J. F. McIntire and H. A. Hamlin, announced that A. C. Wallich, Edward Glanz and J. S. Kilner were elected to serve.

Mr. McConachie thanked the officers and committeemen for their cooperation during his term of office and asked Mr. Paetz to take the chair as president.

The various officers and members of the Board of Governors were called upon and expressed their thanks to the Chapter members.

President Paetz appointed Messrs. Hamlin and Fuller to act as the Auditing Committee and the meeting was then adjourned.

Minnesota

May 15, 1933. The final meeting of the 1932-33 season of the Minnesota Chapter was held at the Golden Valley Golf Club, Minneapolis. Firing began from the first tee at 1:30 p.m. and following the golf tournament dinner was served at 6:30 p.m. after which prizes were awarded by A. J. Huch, for those proficient and otherwise on the fairways, in the traps and on the greens.

Following dinner, the regular business meeting was called to order by Pres. W. F. Uhl and the minutes of the previous meeting were read and approved. The official report of the Nominating Committee for officers for the coming year was given by H. E. Gerrish, chairman, and on motion properly seconded, nominations were called and a unanimous ballot cast by rising vote for the slate as submitted:

President—A. B. Algren.
Vice-President—C. E. Lewis.
Secretary-Treasurer—C. E. Gausman.
Board of Governors (1933-34)—W. F. Uhl and L. C. Gross.

President Uhl brought up the subject of a special summer meeting to be held either July 10 or 11 in accordance with a letter received from E. K. Campbell, chairman of the Chapter Relations Committee, regarding a proposed visit by R. J. Thompson who would present a very interesting talk on the use of Freon as a refrigerant. President Uhl wished to ascertain the possible attendance at such a meeting and after much discussion it was agreed that a noon luncheon might possibly be arranged in conjunction with others interested.

A financial report for the year 1932-33 was given by the treassurer and mention was again made of the excellent meeting at LaCrosse.

The meeting was then adjourned for bridge and other forms of after dinner entertainment.

Philadelphia

May 11, 1933. A very enjoyable day was spent by the members and guests of the Philadelphia Chapter at the Roxboro Country Club and generally the matches were settled at the nineteenth hole. Dinner was served at 7:00 p. m. and then a short business meeting was conducted by Pres. M. F. Blankin.

The minutes of the April meeting were read and approved as was the treasurer's report. Since this was the last meeting of the Chapter until October, the attendance prize was awarded to Karl Rugart.

Golf prizes were awarded to the following members by the chairman of the Meetings Committee: low gross to T. W. Cooper; runner up to M. F. Blankin; low net to C. Miller; runner up to Messrs. Coward, Davidson and Haynes as these three members were tied; kicker's handicap to P. L. Davidson; and high gross to H. G. Black.

Following the awarding of the prizes, J. D. Cassell introduced Dr. Edward J. Cattell, who gave a 30 minute address on Optimism which was most timely and was appreciated by all present.

President Blankin with a few well chosen words thanked W. R. Eichberg, retiring chairman of the Meetings Committee, for his efforts during the past year and Mr. Eichberg in turn expressed his gratitude to the committee for the unusual co operation they had given him and asked the same support for the new chairman, W. F. Smith.

Western Michigan

May 20, 1933. At the annual meeting of the Western Michigan Chapter, held at the Spring Lake Country Club, Spring Lake, Mich., the following officers were elected to serve during the 1933-34 season:

President—K. L. Ziesse.
Vice-President—S. H. Downs.
Secretary—P. O. Wierenga.
Treasurer—Harry Christenson.
Board of Governors—W. W. Bradfield, Cornelius Lammers, J. J. Troske.

Southern California Chapter Sponsors Air Conditioning Meeting and Exhibition

A very successful Air Conditioning Meeting, held in Los Angeles on May 23, and a display of Air Conditioning Equipment, during the week of May 22 28, resulted from the enthusiastic and tireless efforts of members of the Southern California Chapter of the A. S. H. V. E., working in cooperation with the local public utilities companies, the University of Southern California and the Los Angeles Chamber of Commerce.

The meeting was held at the University of Southern California and, in the absence of L. H. Polderman, President of the Southern California Chapter, who was unfortunately detained in Chicago due to illness, Vice-Pres. W. H. C. Ness opened the meeting and presided as chairman. An inspiring message from Mr. Polderman was read to the assembly, after which the technical program was presented.

The first speaker was P. D. Close, who gave a general outline of Air Conditioning and showed charts and slides of results determined by the research work of the Society.

A discussion of New Developments in Refrigeration with relation to air conditioning was given by W. E. Barnum, with particular reference to Freon and its properties.

J. C. Malm spoke on Ice Cooling and gave facts as to initial and operating costs and the applications of this method.

In discussing Air Conditioning for Greenhouses, Citrus and Industrial Plants, E. L. Ellingwood requested that all phases of proper conditioning be given consideration when specifying equipment.

The properties and applications of Silica Gel were described by H. L. Warren, who told of installations which had been made and the results obtained.

A very interesting paper on Sound Insulation and Isolation was presented by V. O. Knudsen, in which he described the most recent methods of measuring sound and of insulation against noise.

E. H. Kendall presented a paper on Unit Type Conditioning, giving the various types and applications of each, as well as installation and operation costs.

Cooling for the World's Largest Mirror was the title of a paper by M. M. Lawler, which explained the conditioning system for the 200-inch mirror at California Institute of Technology.

In a paper on Cooling by Refrigeration, J. F. Kooistra brought out comparative costs and information relative to the design of this type of system.

Heating by Refrigeration was presented by H. H. Douglas, who described the installation in the Southern California Edison Building.

The final paper on the program was a discussion of Heat and Its General Principles of Transmission by R. L. Daugherty.

A display of air conditioning equipment in the Chamber of Commerce Building attracted many visitors during the week and 24 different types of equipment were demonstrated by 17 manufacturers and representatives. Many of the units were in operation and were of particular interest to architects, engineers, building managers, industrialists and home owners who attended.

Dean Anderson on A. S. M. E. Committee

Dean F. Paul Anderson, Lexington, Ky., has been appointed a member of the *A. S. M. E.* Committee No. 10 on Centrifugal and Turbo-Compressors and Blowers.

Council Meets at Detroit

The day preceding the opening of the Semi-Annual Meeting in Detroit, Mich., was reserved for Committee meetings and the Council of the Society gathered at dinner in Hotel Statler, June 21, at 6:20 p. m. with President W. T. Jones presiding and 13 of the 17 members in attendance.

Nominations were made for 5 members of the Committee on Research, reports of several special committees were received, cooperation with the *A. S. M. E.* in their Heat Transfer Symposium was approved, the dates of the 40th annual meeting were selected, and the invitation of Philadelphia Chapter to hold the 1934 summer meeting in Eastern Pennsylvania was accepted. Routine action on reinstatement of membership, resignation and cancellation for non-payment of dues was taken.

Furnace Manufacturers Adopt New Name

At the Spring Meeting of the *National Warm Air Heating Association* held at Hotel Stevens, Chicago, June 5-7, one of the important actions taken was to change the name of the organization to the *National Warm Air Heating and Air Conditioning Association.*

The report on research activities was outlined by Prof. A. C. Willard of the University of Illinois and test data was given by Prof. A. P. Kratz and S. Konzo.

At the Wednesday afternoon Round Table discussion the speakers were: J. H. Van Alsburg, Holland, Mich., Registers and Grilles for Mechanical and Gravity Heating; F. E. Mehrings, Peoria, Ill., The Opportunity for Air Conditioning in Replacement Work; and L. R. Taylor, Utica, N. Y., Rackets in Our Industry.

The Code Committee report was presented by Prof. J. D. Hoffman, Lafayette, Ind. and Harvey Manney outlined the work of the Committee of Ten.

A. O. B. A. Meeting and Show

The 10th Annual Convention of the *American Oil Burner Association* opened June 12 and continued until the 16th at Hotel Stevens, Chicago, Ill. Manufacturers and dealers had special sessions and an exhibition of 70 booths was maintained throughout the week.

Air conditioning was a featured subject in both divisions with L. M. O'Neil, vice president, Air Conditioning Corp., Chicago, speaking on A New Dealer's View of the Oil Burner Industry and Samuel R. Lewis, Consulting Engineer, Chicago, talking on Domestic Air Conditioning during the engineering session Friday.

A booth at the show was maintained by the A. S. H. V. E. and showed graphically the extent of the research work carried on at Yale University by Prof. L. E. Seeley in cooperation with the *A. O. B. A.* The various other Society activities were explained by members of the Illinois Chapter who were in attendance under the chairmanship of R. E. Moore.

Engineers' Week at Chicago

Fifteen engineering societies participated in Engineers Week June 25-30, in Chicago during the Century of Progress. The Mid-West Power Show was held during the same time in the Hotel Stevens and attracted much favorable attention.

At the educational exhibition of the *American Society for Testing Materials* in Hotel Stevens the A. S. H. V. E. had a booth where demonstrations were given of the operation of the Nichols Heat Meter, the hot plate method of testing lumber and the setup used in testing air cleaning devices which is specified in the Society's code. The booth was in charge of F. C. Houghten, director of the A. S. H. V. E. Research Laboratory, assisted by R. W. Shields.

At the Hotel Sherman the *American Society of Refrigerating Engineers* held a three day session and on Tuesday Air Conditioning was the topic of discussion. The papers were: The Residence Cooling Problem by Prof. A. C. Willard and Prof. A. P. Kratz, Urbana, Ill.; Self Contained Room Coolers by C. R. Neeson, Philadelphia; Unit Coolers—Effect of Humidity on Heat Transfer above and below the Freezing Point, by Prof. W. R. Woolrich, P. W. Scates and Mack Turner, Knoxville; Aerodynamics of Air Conditioning, by S. M. Anderson, Boston.

During the *A. S. M. E.* meeting in the Palmer House a committee was organized under *A. S. A.* procedure to unify the rules for dimensioning furnaces burning solid fuel. C. E. Bronson, Kewanee, Ill. was elected chairman and M. G. Bluth, secretary. Thirty six delegates attended representing 20 organizations: J. F. McIntire, Detroit, is the A. S. H. V. E. representative.

Engineers Day was celebrated on Wednesday with all Societies cooperating. The ceremonies started with the presentation of the Daniel Guggenheim Medal to Juan de la Cierva at 10 a. m. in Soldiers Field before a huge throng.

Death of John R. Shanklin

In the death of John Richard Shanklin, on June 13, the Society loses one of its Life Members and the heating industry loses a leader in the contracting field.

Mr. Shanklin was born July 13, 1863, at Union, Monroe County, W. Va., received his schooling in West Virginia and served an apprenticeship in plumbing and heating with Clark Howell at Alderson, W. Va. He had both shop and drafting experience and attended the New York Trade School in 1885. He served with Wallack and Wingate, Atlanta, Ga., and in 1887 became junior partner of Howell and Shanklin, Charleston, W. Va., in which connection he superintended all heating work, which included many of the important buildings in Ohio, Virginia and West Virginia. Later he organized the West Virginia Heating and Plumbing Co., of which he was president and general manager. In his business career of over 50 years he designed and supervised the installations in hundreds of public buildings.

Mr. Shanklin joined the Society in 1899 and has been an active member for over 30 years. He was a regular attendant at Society meetings and many will recall the very pleasant summer meeting at White Sulphur Springs, in which he took an active part as a member of the Entertainment Committee. He was a strong booster for West Virginia and had an intimate knowledge of the history of the state. He was an enthusiastic golfer, and another of his hobbies was the writing of verse, a considerable number of which have been published.

In 1931 Mr. Shanklin announced his retirement from active business, and his son, John A. Shanklin, who has been associated with him for many years, has been active in the management of the firm.

The Officers and Council regret the passing of an old and valued friend and express their sincere sorrow to his family for the loss that they have sustained.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 16 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly **of any whose eligibility for membership is in any way questioned.**

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by July 15, 1933, these candidates will be balloted upon by the Council. Those **elected to membership will be notified by the Secretary immediately after election.**

CANDIDATES	REFERENCES *Proposers*	 *Seconders*
BULLOCK, HOWARD H., Commercial Engr., General Electric Co., Los Angeles, Calif.	W. H. C. Ness	W. E. Barnum, Jr.
	E. H. Kendall	A. B. Simonds
GINI, ALDO, Engr., Milan, Italy.	C. F. Hauss	G. Vitullo—(*Non-Member*)
	E. Donzelli	R. Kuhlmann
HALLAS, ROBERT S., Student, Case School of Applied Science, Cleveland, O.	G. L. Tuve	F. H. Vose —(*A. S. M. E.*)
	R. H. Wehrle	E. S. Ault—(*Non-Member*)
HARTMAN, F. S., Dist. Mgr., Ind. Dept., General Electric Co., New York, N. Y.	W. H. Driscoll	C. S. Hoffman
	J. I. Lyle	C. R. Place
	W. H. Carrier	E. E. Ashley, Jr.
KARTORIE, V. T., Student, Case School of Applied Science, Cleveland, O.	R. H. Wehrle	G. B. Carson—(*Non-Member*)
	C. A. McKeeman—(*Non-Member*)	E. S. Ault—(*Non-Member*)
MONTGOMERY, ORA C., Asst. Supt. of Power, N. Y. Central R. R., New York, N. Y.	W. H. Driscoll	C. R. Place
	W. W. Timmis	W. S. Koithan
NEU, H. J. E., Pres., Société Anonyme des Etablissements Neu, Lille, France.	A. Beaurrienne	J. Rey—(*Non-Member*)
	A. Nessi	L. Danel—(*Non-Member*)
PRICE, CHARLES E., Editor, *Heating, Piping and Air Conditioning*, Chicago, Ill.	John Howatt	R. E. Hattis
	F. P. Keeney	J. H. Milliken
QUINLIVAN, LAURENCE P., Student, Case School of Applied Science, Cleveland, O.	R. H. Wehrle	F. H. Vose—(*A. S. M. E.*)
	G. L. Tuve	E. S. Ault—(*Non-Member*)
RAMSEY, RAYMOND F., Student, Case School of Applied Science, Cleveland, O.	R. H. Wehrle	F. H. Vose—(*A. S. M. E.*)
	G. L. Tuve	E. S. Ault—(*Non-Member*)
REINKE, ALFRED G., Instrument Maker, Westinghouse Elec. & Mfg. Co., Newark, N. J.	J. F. Sinn—(*Non-Member*)	W. F. Pfeiffer—(*Non-Member*)
	P. D. Brewster—(*Non-Mbr.*)	J. A. Martina—(*Non-Member*)
SAWYER, J. NEAL, Field Engr., Holland Furnace Co., Kansas City, Mo.	D. D. Zink	W. E. Gillham
	E. K. Campbell, Jr.	Carl Clegg
SCOTT, WILLIAM P., JR., Htg. Estimator, Scott Co., San Francisco, Calif.	W. E. Leland	
	H. S. Haley	J. I. Krueger
SEVERNS, WILLIAM H., Prof. of Mech. Engrg., University of Illinois, Urbana, Ill.	A. C. Willard	M. K. Fahnestock
	A. P. Kratz	S. Konzo
TORR, THOMAS W., Chief Engr., Rudy Furnace Co., Dowagiac, Mich.	J. H. Van Alsburg	C. R. McConner
	S. H. Downs	D. L. Taze
YEAGER, GEORGE F., Inspector, Test Dept., Penn. R. R., Altoona, Pa.	F. C. Houghten	W. K. Simpson
	C. V. Haynes	J. I. Lyle

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BARRY, JAMES, JR., Vice-Pres., Elliott & Barry Engrg. Co., St. Louis, Mo.

HANLEY, THOMAS F., JR., Pres., Hanley & Co., Chicago, Ill.

KOETZ, LESTER, Sales Engr., Zion Institutions & Industries, Inc., Zion, Ill. (*Advancement*)

STROBL, J. A., Est. and Engr., Kirk & Blum Mfg. Co., Cincinnati, O.

SYSKA, ADOLPH G., Partner, Syska & Hennessy, New York, N. Y.

TOUTON, R. D., Tech. Dir., Bayuk Cigars, Inc., Philadelphia, Pa.

ASSOCIATES

KOHLER, WALTER J., JR., Supervisor, Kohler Co., Kohler, Wis.

KRAMIG, ROBERT E., JR., Junior Member, R. E. Kramig & Co., Cincinnati, O.

VANDERHOOF, A. L., Pres., A. L. Vanderhoof, Inc., Cleveland, O.

JUNIORS

FINERAN, EDWARD V., Laboratory Engr., Washington Gas Light Co., Washington, D. C.

LIBBY, RALPH S., B. C. Electric Power & Gas Co., Vancouv B. C.

NITSCHKE, ROBERT C., Engr. & Draftsman, Socony-Vacuu Corp., New York, N. Y.

HEAT
HUMIDITY
DEAD AIR
DUST

This AIR RAID STOPPED

by Westinghouse AIR CONDITIONING

Plenty of cool, fresh air at the touch of a switch builds profitable business. The high-type Westinghouse Unit with Modernistic Micarta finish is shown here.

HEAT, humidity, dead air and dust . . . these foes of profitable business launch their withering attack on the cash registers of stores, shops, offices, and restaurants.

But, with *complete* air conditioning, provided by the new Westinghouse units, these raiders can now be banished. Depressing heat and humidity are replaced by cool, invigorating air which increases business.

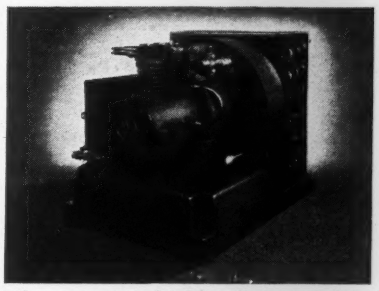
The Westinghouse Units do more than merely cool in summer; they provide *completely* conditioned air all year 'round—air that is cooled and de-humidified in summer, heated and humidified in winter, cleaned and circulated at all times.

To meet individual requirements with greatest economy, Westinghouse provides a complete line of sizes and ratings of units for floor, wall or ceiling mounting, available in finishes to harmonize with other interior furnishings. Refrigeration units are made in four sizes—air or water-cooled.

No other air conditioning unit equipment offers so many advantages—beauty, dependability, economy, variety. Westinghouse equipment is readily installed, easy to operate, quiet, and fully guaranteed.

Let us send you our free booklet "Air Conditioning for Health, Comfort and Profit," describing the complete line of Westinghouse Units.

The low-type cabinet, Walnut Burl finish, for mounting under windows or along the wall.



The compact, highly efficient Refrigeration Unit is placed in the basement or in a nearby room.

Westinghouse

Unit Air Conditioning

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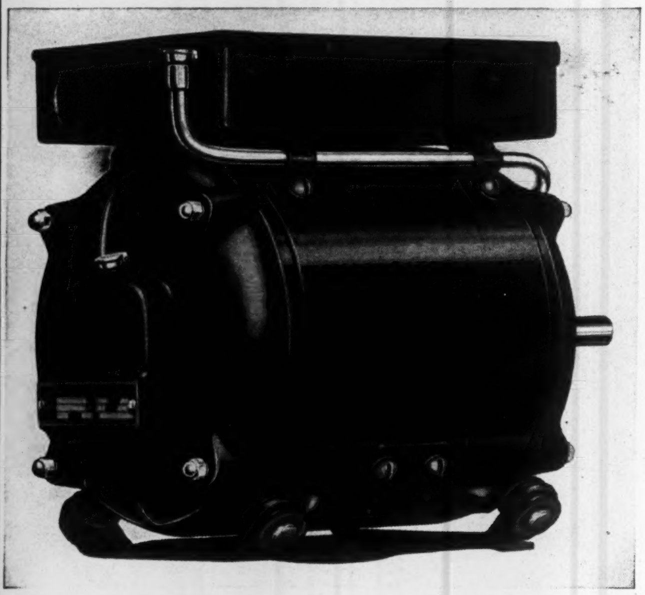
NEW Emerson Capacitor Motors for Air Conditioning



ALL the advantages of repulsion induction motors.

Plus
Extreme Quietness
Simplified Construction
No Brushes
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Condenser and outlet box on field ring or separate if desired.

Extra large oil wells. Frames interchangeable for A.C. and D.C.

Resilient mountings in sizes 1/8 to 1/3 h.p.; 1/8 to 1/2 h.p. with rigid mountings.

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2018 Washington Ave., Saint Louis
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EMERSON MOTORS

For Fan Duty or Blower Service, 3 h.p. and smaller. Split Phase, Capacitor, Induction repulsion, Polyphase and D.C.

What Does the Term "Air Conditioning" Mean?

THE EDITOR:

ON account of a discussion coming up between several parties on two or three different jobs in this city I am anxious to find out what the term "air conditioning" means.

"It might be that you know of some engineering society that has adopted a code, and if you have any information regarding this subject, I will be very pleased to receive it."

—F. H. C., *Consulting Engineer*, New Orleans, La.

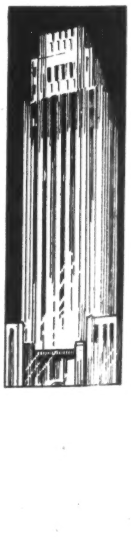
The *American Society of Heating and Ventilating Engineers'* definition of the term *air conditioning* (as it applies to comfort conditioning) is given in the *A. S. H. V. E. Guide 1933*, page 557, and is as follows:

> "The simultaneous control of all or at least the first three of those factors affecting both the physical and chemical conditions of the atmosphere within any structure. These factors include temperature, humidity, motion, distribution, dust, bacteria, odors, toxic gases, and ionization, most of which affect in greater or lesser degree human health or comfort."

This same definition appears also in the report of the *A. S. H. V. E.* committee on ventilation standards (HEATING, PIPING AND AIR CONDITIONING, August, 1932, page 576).

Recently W. H. Driscoll, vice-president, Thompson-Starrett Company, Inc., New York City, stated that the term *ventilation* will ultimately be limited in its meaning to the changing of air in mines, industrial plants, toilets and places where air change is the primary factor to be considered. In amplifying this statement, Mr. Driscoll writes:

> "The term *air conditioning* implies quality primarily, with quantity as a minor factor. It is well established that the air requirements for human health and comfort, as well as for the improvement of many manufacturing processes, make temperature, humidity and motion of air the factors of primary importance. The correction and control of these factors is *air conditioning.*
>
> "The term *ventilation* has no such meaning. Webster's dictionary defines it as follows: 'To cause fresh air to circulate through a room, mine, etc., so as to replace foul air simultaneously removed.'
>
> "In other words, *ventilation* means *air quantity* only, and has nothing to do with air's physical properties.
>
> "This meaning has grown out of the entirely erroneous conception that it was the chemical composition of the air, as affected by respiration, that was the cause of pollution and that, to correct this condition, it was necessary to keep replacing the air. Inasmuch as there is no longer any doubt that this theory is unsound and that the end to be attained is not so much the removal and replacement of the air, as it is the maintenance of proper physical conditions, this emphasizes the matter of quality, rather than of quantity, and the control of the quality is *air conditioning.*
>
> "The ventilation of mines, the removal of smoke, dusts and gases from industrial plants, the removal of odors from toilets, manufacturing plants, etc., all of these are accomplished by the removal and replacement of air, and that is *ventilation.*"



Equipment—

(Continued from page 366, Editorial Section)

The non-portable room coolers do the same work but are not self-contained. The refrigeration compressors in this case are installed remote from the room in which the cooler cabinet is mounted. Because of this, the room cabinets weigh less and can be mounted on the wall. For this type separate connections are required both for the cabinet and the compressor. The cabinet connections consist of two small refrigerant lines, a drain and an electric power line. The connections for the compressor comprise electric power and two pipe lines for the water-cooling system.

The 1-ton compressor is driven by a 2-hp motor. The room cabinet can be either wall-mounted, for delivering the cooled air horizontally, or floor-mounted, in which case the air current will be vertical. A 2-ton compressor is also available which will supply two room cabinets.

The complete conditioner heats and humidifies in winter and cools and dehumidifies in summer. Equipment which the unit contains consists of heating and cooling surfaces, humidifier, filter, and noise silencer. Outside air can be varied from zero up to fifty per cent of the total air handled. Connections necessary are water supply, drainage, electricity, steam supply, steam condensate drain, condensate drain from cooling coils, and ventilation air duct. The compressor is in the cabinet. The unit's capacity is ⅔ of a ton of refrigeration for cooling and 40 sq ft for heating. The change from winter service to summer service is effected by throwing a switch and adjusting a water valve.

The company will also have ready for installation this year a central air-conditioning system, which will comprise a cooling and dehumidifying system to be combined with the present winter air-conditioning system. This will be built and installed according to the conditions of each building to be equipped, and ducts will convey the air.

Offers New Trap

The Sarco Co., New York City, is offering a new trap designed especially to handle condensation in large quantities and in sudden rushes, as with unit heaters, pipe coils and the like. It has a 1½-in. inlet and outlet. Inlet and outlet are in front, a vertical distance of 3 in. apart.

All working parts are on the cover and accessible by removing the trap body without disturbing pipe connections. A boss is provided on top of the body, in line with the cleaning-out plug, for installation of a gage glass when desired.

The standard trap is suitable for pressures of 0-10 lb, but the trap can also be furnished for pressures from 10 to 60 lb.

The thermostatic valve in this trap is designed to prevent air binding.

Announces Damper Motor, Thermostat

Russell Electric Company, 348 W. Huron St., Chicago, has recently announced two new items—one is a room thermostat and the other an electric damper motor.

The thermostat has a quick make-and-break action which is obtained on both the high and low side by means of a magnet, to eliminate radio interference and relay chattering. Pure silver contacts of large area are used and are located within a dead-air space on the top of the instrument to keep them clean and protect them from dust. Wiring connections are made to binding posts on the back of the thermostat.

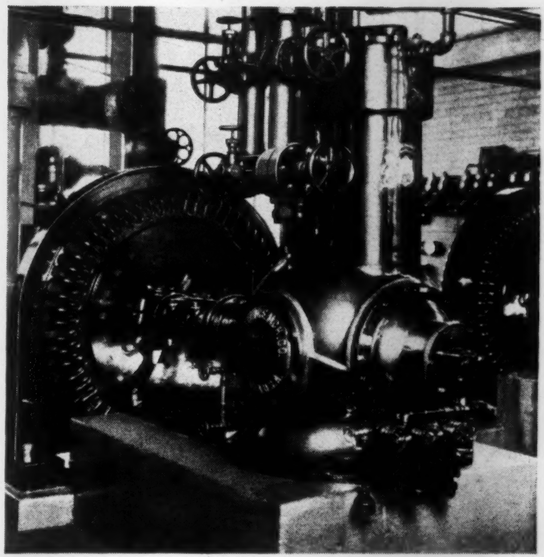
The thermostats are of the low-voltage type supplied for two- or three-wire circuits. Calibration is guaranteed to be accurate to 1 F (one-half scale division).

The damper motor employs a high torque four-pole induction motor, with a squirrel-cage rotor 1½ in. in diameter. The shaft

---back your judgment with

BAKER

Refrigeration



there's a Baker Machine to fit every air-conditioning need . . . .

When you specify refrigerating equipment for an air-conditioning job, your prestige and reputation depend upon the correctness of your choice. And there are good reasons why it is safe, and wise, to use Baker equipment.

Because Baker has equipment which offers the things you want . . . economy of operation . . . twenty-four hour, year-in-and-year-out dependability . . . easy control by automatic instruments . . . and all the exclusive improvements which have been developed by Baker in twenty-eight years of building quality refrigeration for all the world.

Ask us more about Baker—our entire organization is at your service without obligation.

BAKER

ICE MACHINE CO., Inc.

1590 Evans St. Omaha, Neb.

Factories: Omaha Ft. Worth Los Angeles Seattle

AIR CONDITIONING

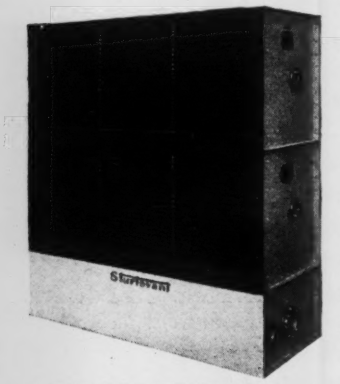
"Made-to-Order Climate"

in all its branches by

STURTEVANT

. . . pioneers in
Cooling and Air Conditioning

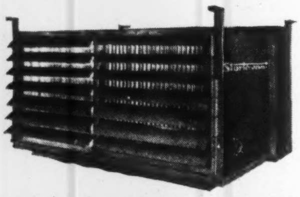
WHETHER it is one room of limited size or an entire building—comfort conditioning or industrial processing, there is Sturtevant air conditioning equipment which can be applied with complete assurance of the correct results. Not just one unit to handle all applications, but a full line of equipment which includes individual units to meet specific requirements, through to complete central systems.



STURTEVANT FILTICOOLER

There is the Filticooler, a unit which will filter, wash, humidify, and cool or dehumidify air. Its application is especially desirable for those areas such as food packing plants, and laboratories, where the conditioned air must be kept free of dust, dirt and bacteria. It can readily be fitted into the duct of an existing ventilating system and transform it into an air conditioning system, something to keep in mind for a modernizing project.

Another popular unit is the Suspended Type Air Conditioner. Consider just one feature of this unit. When operating as a cooler it does not frost, and the de-frosting cycle so necessary with the commonly conceived unit cooler is not necessary. Furthermore, it is installed suspended from the ceiling or beams, out of the way.



SUSPENDED TYPE AIR CONDITIONER

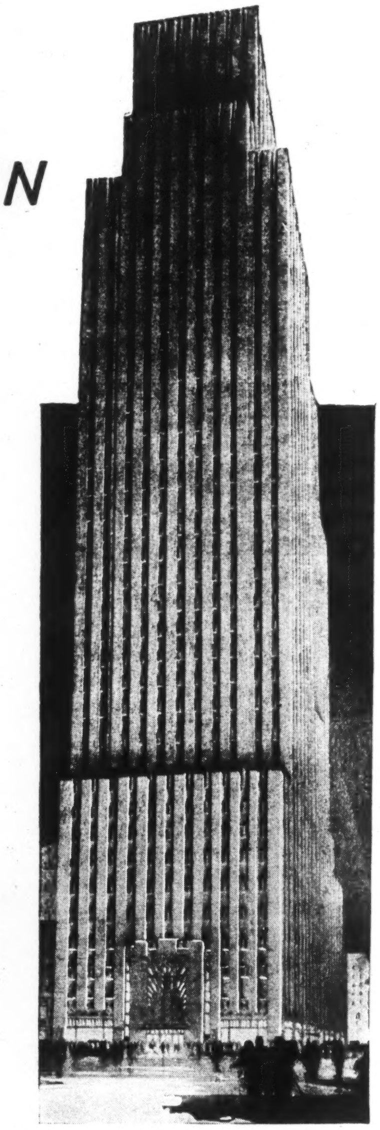
Other units operate as combination heaters and humidifiers, heaters and coolers, and humidifiers only for industrial, office and residential applications. They all play an important part in the present day modernizing programs, which are being planned. Let us work with you on any project you have or are contemplating.

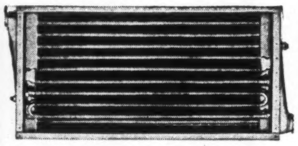
Sturtevant
REG. U. S. PAT. OFF.
B. F. STURTEVANT COMPANY, HYDE PARK, BOSTON, MASS.

"Made-to-Order Climate" for all purposes

AEROFIN
IS THE HEAT-SURFACE
FOUND IN THE

NEWS
BUILDING
NEW YORK CITY





The Standardized Light-Weight Fan System Heat-Surface

4 Types 196 Standard Sizes

A comprehensive and helpful Bulletin will be mailed without charge upon request to Newark. Please use your business letterhead and ask for Bulletin 32.

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This is not happenstance. *AEROFIN* is selected by America's foremost Architects and Engineers because of its *proved* superiority. Pioneering lightweight, non-corrodible, *unit* Fan System Heat-Surface years in advance *AEROFIN*, designed and constantly improved by Fan Engineers, is still years in advance. Newark will be glad to send informative and appropriate publications upon request. Any Office will gladly render prompt, efficient, technical cooperation.

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List upon Request

AEROFIN CORPORATION
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Chicago Detroit New York Philadelphia

is ¼ in. in diameter. Among the other features is the wide spacing between the crank pin centers and the use of a long crank moving through a small angle to provide a motion of 3 in. at the end of the arm, at the same time reducing the angularity. The damper motor is rated at a 25-lb load with 75 in.-lb. torque.

Internal design is "wireless"; all external connections are made on an insulated panel inside the bakelite cover. The case is of steel, electrically welded and finished in baked black japan.

New Indicator Gage

A new indicator gage made by Morey & Jones, Ltd., Los Angeles, Calif., is designed to fill a need for a reasonably-priced instrument for accurately indicating rates of flow and differentials; it may also be used as a level indicator for showing liquid levels in tanks above ground.

It is a mechanically operated, direct-reading dial gage actuated by a metallic bellows located in a small chamber back of the dial case. Calibration may be in inches differential, in gpm of flow, or other readings for flow service, as required.

0
1
2
3
4
5
6
7
8
9
10
DIFFERENTIAL PRESSURE
MOREY & JONES, LTD
LOS ANGELES, CAL.

The indicator is built to withstand 250 lb per sq in. maximum working pressure, and is manufactured for differential pressures ranging from about 5 inches of mercury to 25 lb, using suitable springs. Accuracy is within 1½ per cent, greater accuracy being attainable under the higher differentials. The indicator is suitable for operation from any standard orifice, Venturi tube, nozzle, or other means of creating a differential.

CO$_2$ Recorders Improved

Improved one-, two- and three-pen automatic CO$_2$ recorders have been announced by Defender Automatic Regulator Co., St. Louis, Mo.

A new 8-page bulletin illustrates the self-contained and long distance stationary types for permanent mounting in boiler rooms and a new 4-page bulletin illustrates three portable-types with one, two- or three-pens for reading the per cent CO$_2$ furnace draft and flue gas temperature.

A small knurled thumb screw has been added to the top of the vertical pendulum weight which balances the pen arm so as to allow the instrument to be quickly calibrated or adjusted so as to read accurately. Two new pipes are now attached to the top and bottom of the bell float tank, one for an overflow and the other for a bottom drain. The vacuum tube is now connected from the bottom of this bell float to the center of the porous plate which is secured to the top of the KOH tank, which is mounted in the bottom of the case.

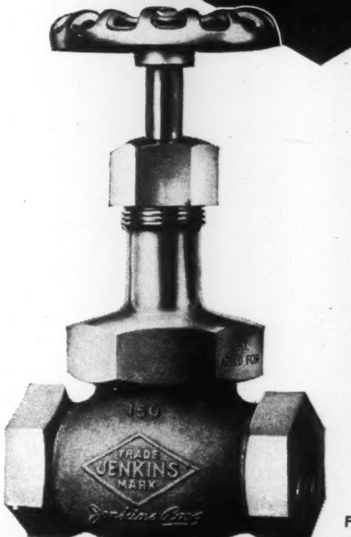
Another improvement is the location of the small universal motor and the centrifugal gas pump on a removable shelf in the center of the case. With each portable instrument there is supplied a small size specially designed Orsat which can be hung on the side of the case to test the instrument when calibrating it. The complete apparatus weighs 30 lb.

This company has also announced an improved line of adjustable chronometer valves for regulation or control of hot or cold fluids such as high-temperature oils, chemicals, superheated steam, etc.

These valves are adjustable from the outside by tightening or loosening a nut on the end of the valve stem so as to allow the

Always marked with the "Diamond"

Jenkins
BRONZE IRON STEEL
VALVES
Since 1864

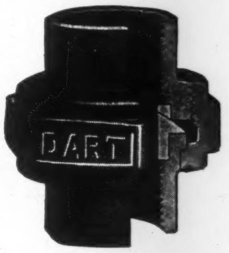


THERE is QUALITY in Fig. 106-A Jenkins Bronze Globe Valve—extra deep stuffing box—slip-on, stay-on disc holder—one-piece screw-over bonnet—Jenkins disc. It pays to insist on Jenkins Valves and the extra service that has characterized Jenkins quality since 1864.

JENKINS BROS.
80 White Street, New York, N. Y.
Bridgeport, Conn. Boston, Mass.
Chicago, Ill. Philadelphia, Pa.

Fig. 106-A Globe, Screwed

Obtainable through your supply house



LONG LIFE
PIPING JOBS
with
DART
UNIONS

» » LOOK beyond the material you buy. If you do not find that there lies a reputation for fine quality—service—the initiative for advancement and improvement and fair dealing, then you must protect yourself.

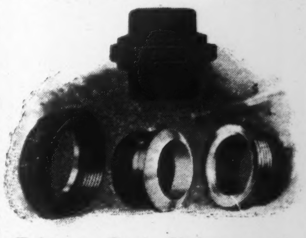
The reason so many Dart Unions are written into original specifications and used as standard by so many Piping Contractors, is because behind them lies these important things—quality—service.

E. M. DART MFG. CO.
PROVIDENCE, R. I.

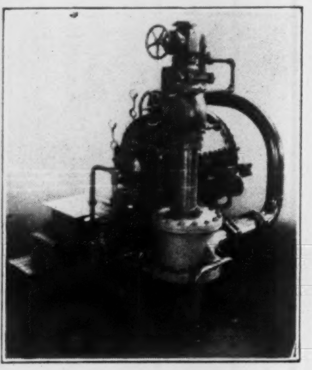
Sales Agents: THE FAIRBANKS CO., New York Branches.

Canadian Factory: DART UNION CO., Ltd., Toronto, Canada.

TAKE A DART APART



Take a Dart Union apart yourself and study it. Note especially the 2 bronze seats. See how carefully they have been ground until a perfect fit results.



A VILTER ROTARY OF THIS TYPE, USING FREON IS INSTALLED IN THE AIR CONDITIONING PLANT AT "Old Heidelberg Inn" *at the* Chicago World's Fair

Vilter Rotary Compressors used in supplying refrigeration in air conditioning plants wherein Freon is used as a refrigerant, are described in Vilter Bulletin No. 45. Freon being non-toxic, non-inflammable, and non-corrosive, is a "safe" refrigerant for this work, and a Vilter Rotary Compressor is ideal for this class of service.

THE Vilter MFG. CO.
2124 S. FIRST ST.
MILWAUKEE, WIS.

BUILDERS OF REFRIGERATING MACHINERY FOR 50 YEARS

HOFFMAN

now offers the **MOST COMPLETE LINE** *of* **STEAM HEATING SPECIALTIES**

VALVES
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PUMPS

FOR EVERY TYPE OF STEAM HEATING SYSTEM

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Hoffman Specialty Co., Inc., Waterbury, Conn.

valve to work free on high-temperature fluids. They are a cone or V type. The liquid passes through port holes so that there are no seats. Size of the port holes increases or decreases as the lever on the valve stem is turned.

The valves are supplied in sizes from ½ to 4 in. in steam bronze, cast iron or steel with hard bronze valve stems. The larger sizes are supplied in either screw or flanged ends and in the plain form, which is a semi-balanced type, and in the yoke type.

Announces Arc Welding Development

A development in arc welding particularly suited to the joining of heavy plates has been announced by the Metal & Thermit Corporation, 120 Broadway, New York City; it is known as straight-gap welding, and does away with the need for "veeing" or grooving of plate edges. The developers of the process say that it cuts welding time in half, and, by eliminating preparatory work and reducing the quantity of weld metal required, achieves economy in welding heavy plates. In addition, it is stated, tests conducted by outside laboratories show that straight-gap welds are physically superior in many ways.

This company has also announced an addition to its line of heavy mineral-coated electrodes. The new unit is for use on mild steel and may be employed in either flat, vertical, or overhead work.

Low Cost X-Ray Paper

For use in industrial X-ray work, St. John X-Ray Corporation, 505 Fifth Ave., New York City, has made available an X-ray paper. Its features, according to the manufacturer, are ease in handling, low cost, fast drying, and it requires but one intensifying screen. The manufacturer also states that it is just as fast as film and gives the same contrast. Developing time is three minutes at 68 F when using special chemicals.

Two sheets are exposed simultaneously in one cassette, so that one negative can be retained while the other goes along with the material.

New Water Treatment

D. W. Haering & Company, water consultants, 3408 W. Monroe St., Chicago, has recently applied its methods of corrosion prevention to air-conditioning equipment. A series of experiments has determined that the chemical nature of the water in the circulating system of this type of equipment, if compared with data on the volume of air passed and the amount of make-up water used, gives a true average indication of the type and volume of corrective treatment necessary.

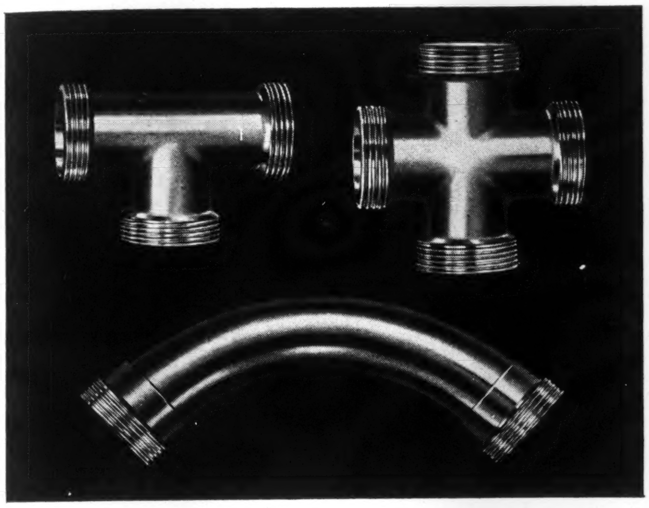
The company makes a daily analysis of this water and collects the data over a period of one week and from this material is able to calculate the amount of corrective treatment required. Treatment is based on the volume of air passed through the air-conditioning equipment rather than on the amount of water used and is most effective when introduced continuously, although intermittent treatment may be used when necessary.

The formulas have the necessary property of combining directly with oxygen and acting as buffers to establish prolonged pH control. Correct pH is initially established as a matter of course. No coatings are formed with this treatment, it is said.

Four New Burners

Four new burners are the subjects of announcements which have been made by The Babcock & Wilcox Company, 85 Liberty St., New York City. The first is a combination oil-and-gas burner in which is combined the features of the company's mechanical atomizing oil burner with a method of burning gas. The gas is broken up into small streams and is discharged at right angles into a venturi throat through which the air for combustion passes for complete mixing and rapid combustion. The burner is

PITTSBURGH PIPING
Fabricators of
STAINLESS STEEL



HAVE you considered the advantages of stainless and special alloy steels?

Everywhere your attention is directed to alloys—their longer life and greater strength point the way to savings.

Are you taking advantage of the possibilities of these special steels by putting them to work in your plant?

PITTSBURGH PIPING & EQUIPMENT COMPANY, specializing in welded fabrication, is able to supply any special stainless alloy equipment to your specifications.

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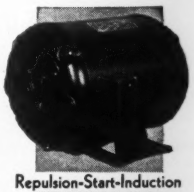
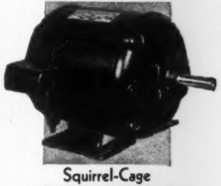
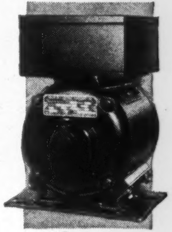
You can Standardize on Wagner Motors



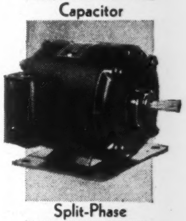
Repulsion-Start-Induction



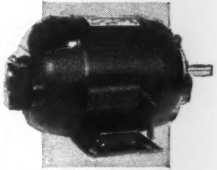
Squirrel-Cage



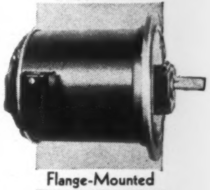
Capacitor



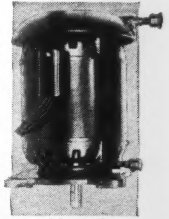
Split-Phase



Direct-Current



Flange-Mounted



Vertical

The Wagner line includes all types of small motors generally applied on motor-driven machinery, making it possible for you to standardize on Wagner motors. Whether alternating or direct current; single or polyphase; open, drip-proof, totally enclosed or explosion-proof; rigid or resilient-mounted, flange-mounted or built-in; sleeve or ball-bearing; horizontal or vertical—there's a Wagner motor now in existence, ready to be applied on the job.

There are 25,000 different type-horsepower-speed combinations of Wagner motors (in ratings up to 400 hp). Certainly, your motor requirements are no greater than that!

For complete details, ask for Bulletin 167 describing Wagner small motors.

Wagner Electric
MOTORS
TRANSFORMERS
FANS BRAKES

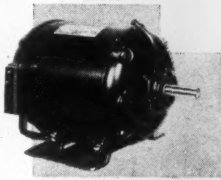
Wagner Electric Corporation
6370 Plymouth Ave., St. Louis, Mo.
Gentlemen;
Please send copy of Bulletin 167 on small motors

If interested also in large motors, indicate here ☐

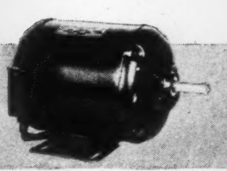
Name and Position ____________

Firm ____________

Address ____________



Resilient-Mounted



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ARMSTRONG TRAPS (Original Inverted Bucket Type)

For any capacity and for any use

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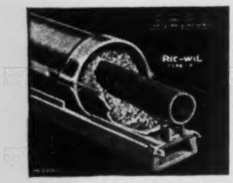
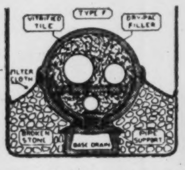
Stocks in all Principal Cities





Ric-wiL Tile Conduit, Type F, insulated with Dry-paC.

RIC-WIL TILE CONDUIT with Loc-liP Side Joint, is a complete Conduit System providing ample protection for underground steam and hot water pipes. Completely engineered, it eliminates extras.

DRY-PAC INSULATION is waterproofed, thus keeping steam pipes dry and maintaining the highest thermal efficiency. Write for complete details.

Tile Ric-wiL, Type F, with three pipes.

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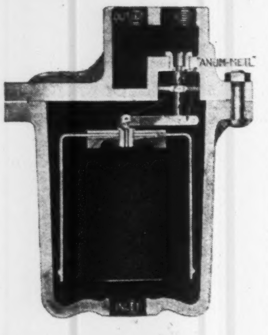
1562 Union Trust Building · · · · · Cleveland, Ohio
Branches: New York - San Francisco - Chicago
AGENTS IN PRINCIPAL CITIES
REG. U. S. PAT. OFF.
RIC-WIL
CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

Here it is:—the Convectofin Heating Element. No more worry about heating capacity.

New Heating Data

Our data "Certified Performance" contains information that has never before been available. Unbiased, independent proof of Convectofin superiority. Tells just what may be expected from this remarkable heater as compared with old fashioned radiators. Saves material, labor, and dollars. 15 pieces less to install. Write.

COMMODORE HEATERS CORP.
11 West 42nd St. New York City



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Anti-Balancing

Guaranteed for One Year Against Wear

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1392 WEST 3RD ST. CLEVELAND, OHIO

made in heat-liberation capacities up to 70,000,000 Btu per h per burner using natural gas.

The second is a circular multi-fuels burner which is adapted t combination firing through refractory burner-walls and is suite to small- and moderate-size industrial-boiler units. The burner, which is of the horizontal turbulent type, combines the feature of the company's circular burner and mechanical atomizing oi burner, together with such additions as are necessary for the efficient burning of gas. Liquid, gaseous or solid fuels in pulverized form may be injected into the furnace through a common circular throat opening, either one at a time, or in combination. The adjustable deflector, mounted at the furnace end of the primary-air and pulverized-coal pipe, insures intimate mixing with the secondary air and furnishes a high degree of turbulence, says the manufacturer.

The third is a combination pulverized-coal and oil burner which meets the requirements of such an installation in water-cooled furnace walls. The pulverized-coal burner is this company's standard multiple intertube burner. The oil burner is of the twin-nozzle type and is inserted between two tubes in front of the pulverized-coal burner, extending back and through the burner casing, supported by a guide trough between the casing and the burner tip. The oil-burner tips are set so that the oil is distributed across the air stream to obtain a satisfactory mixture of fuel and air.

The fourth type which has recently been announced is an oil burner that can be easily and quickly adjusted to operate over a wide range of capacities. The fuel oil is delivered to the burner tip through two passages, an outer annular passage carrying the primary oil stream and the center oil barrel carrying the secondary oil. Both primary and secondary oil meet at one nozzle and a sprayer plate at the burner tip. Changes in capacity with a given nozzle and sprayer plate are secured by operating at low capacities with primary oil alone, and at higher capacities with primary and secondary oil together. A capacity variation of four to one with any one combination of a sprayer plate and its nozzle may be secured.

Recent Trade Literature

Air Compressors: Allis-Chalmers Manufacturing Company, Milwaukee, Wis. 4-p. bulletin relating to single-stage water-cooled rotary air compressors and vacuum pumps of the multi cellular, sliding-vane type, having a range of volumes up to 2,000 cfm, at pressures up to 150 lb. and vacuums to 29.85 in.

Air Conditioning: Frigidaire Corporation, Dayton, Ohio, 32-p. bulletin, with diagrams and photos, containing information on air conditioning for architects, engineers, and contractors, including commercial, office and industrial applications. Typical installations are diagrammed and the company's equipment is described.

Air Conditioning: Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Illustrated 16-p. booklet on air conditioning for health, comfort and profit giving a general description of this company's air-conditioning equipment and information about the applications of unit air conditioners.

Air Conditioning: York Ice Machinery Corporation, York, Pa. Data sheet for floor-type air conditioners. Also an 8-p. booklet telling advantages of air conditioning and showing unit and central equipment.

Air Conditioners: The De La Vergne Engine Co., Philadelphia, Pa. 12-p. bulletin describing and illustrating new unit air conditioners for summer and winter.

Air Handling Equipment: Establissements Neu, Lille, France. Folder illustrating fans, blowers and compressors for handling air at low, high, and "very high" pressures.

Belting: E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa. Wall chart, 24 x 36 in., on the care of leather belt, including dressing, fastening, lacing, how to put on a belt, width of belt necessary, rules for figuring speed, pulley ratios, etc.

Convectors: American Radiator Company, 40 W. 40th St., New York City. 16-p. technical bulletin describing the features

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Using cold water, brine, ammonia, methyl chloride or freon—there is a Buffalo Unit Cooler for cooling of store, an office, a factory—or a storehouse.

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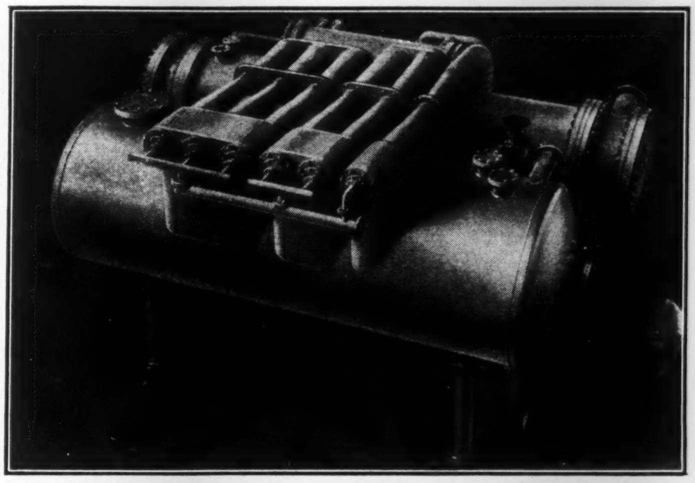
"ROSS" Decalorator

TRADE MARK

Product—Modern steam-vacuum refrigerating apparatus offered by American Blower Corporation for air conditioning and process work in industries requiring chilled water at temperatures from 35° to 60° F.



Important Installations—Above shows type of ***Decalorator*** installed in conjunction with ***Sirocco*** air conditioning systems in such representative structures as British Empire Building, Rockefeller Center, New York City, and First National Bank Building, No. 2 Wall Street, New York City.

Operating Characteristics—The action of a Decalorator is as follows: chilled or decalorated water is produced in a Decalorator by the practical application of an age old and well known physical law, namely—water under high vacuum will vaporize at low temperatures. To produce evaporation, the sensible heat of the liquid is given up in the form of latent heat in the vapor. Chilling of the liquid is consequent to this conversion of heat. Water is chilled in a Decalorator by the maintenance of a high vacuum in a vessel into which water is sprayed. Condensers of the power plant type operating in conjunction with highly efficient steam ejectors produce the vacuum. Decalorators are available in sizes with cooling capacity from 24,000 B. T. U. to 48,000,000 B. T. U. per hour.

Outstanding Advantages—***A Decalorator has no moving parts.*** Consequently, lubricating costs, mechanical replacements and breakdowns resulting therefrom are entirely eliminated. Water is the only refrigerant used, which means safe, healthful cooling under all conditions and freedom from all odors. Live loads need not be considered in the foundation design. Can be operated by anyone capable of operating an ordinary steam boiler. Unusually low installation and operating costs. Only the simplest character of low and medium pressure piping is required. Any reputable heating and piping contractor is fully equipped to install a Decalorator.

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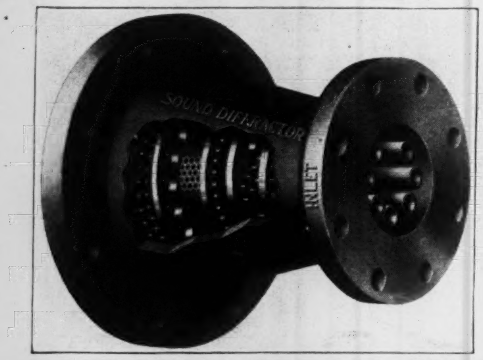

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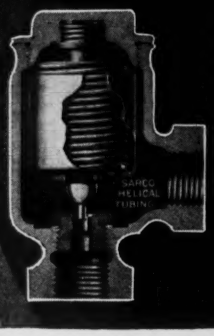

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Simply screw the Sarco Steam Trap into your pipe-line. It is self-adjusting for pressures from 0 to 100 lbs. That saves time. Saves work.

It drains all condensation as soon as formed. Doesn't leak — doesn't waste steam. Cannot air bind.

It costs about one-third the price of big bucket or float traps. Sold on 30 days' free trial. Booklet 0-95 on request.

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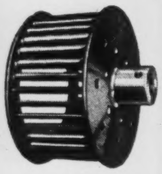

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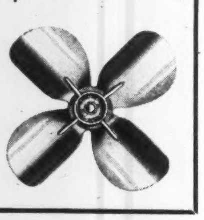

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of convectors (in four widths—3¾, 5⅝, 7⅝, and 9½ in.) and giving ratings and detailed dimensions. Conversion factors for specified hot-water temperatures and information on enclosures are also presented.

Condensation Meters: American District Steam Company, North Tonawanda, N. Y. 12-p. bulletin containing complete information regarding construction, application, features, testing, maintenance, and installation methods for rotary condensation meters for measuring steam consumption of heating systems, hot-water heaters, cooking and laundry equipment, heat exchangers, etc., and measuring industrial process liquids.

Control: Julien P. Friez & Sons, Inc., Baltimore, Md. 4-p. bulletin on complete control assemblies for air conditioning, illustrating the various types and auxiliary instruments. 2-p. data sheet on relative humidity indicators. 4-p. bulletin on humidistats. 2-p. sheet describing a hygro-thermograph.

Combustible Gas Analyzers: Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa. 6-p. folder describing a combustible gas analyzer for testing furnace atmosphere, including features of construction and design and principle of operation.

Electric Heating Elements: Harold F. Trent Company, 618 N. 54th St., Philadelphia, Pa. 4-p. bulletin describing and giving specifications for electric heating units and strip heaters for industrial process work.

Evaporators: York Ice Machinery Corporation, York, Pa. Two data sheets, one on spiral-fin evaporators for refrigeration and the other on square-fin evaporators. Notes on design and arrangement are given.

Fans: B. F. Sturtevant Company, Hyde Park, Boston, Mass. 12-p. catalog of forced-draft fans, including tables of dimensions and performance curves.

Gas Burning: Lee B. Mettler Co., 406 S. Main St., Los Angeles, Calif. 32-p. well illustrated catalog on entrained-combustion gas burners, describing and explaining the principles and showing typical applications. Auxiliary equipment and combination gas and oil burners are described.

Gas Leakage: E. I. Du Pont de Nemours & Co. (Formaldehyde and Chlorine Products Section), Wilmington, Del. 8-p reprint on the hazards of gas leakage as affected by ventilation, being a discussion of the effect of ventilation on the concentration of escaping gas, and possible toxicity and flammability hazards, with special reference to methyl chloride.

Heating System Modernization: American Radiator Company, 40 W. 40th St., New York City. Case book of reports on apartment and tenement buildings presenting the detailed results of modernization of the heating systems of the properties.

Humidifying Radiators: Crouse-Pope Foundry, Auburn, N. Y. Leaflet describing humidifying radiators for steam and hot-water systems.

Malt Cleaners and Mills: Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Leaflet covering malt cleaners and malt mills for breweries and malt houses. Featured are standard units ranging in capacity from 100 to 530 bushels per hour, showing several methods of electric motor drive and flexibility of the units.

Molding Material: Bakelite Corporation, 247 Park Ave., New York City. Circular describing a new molding material with high impact strength.

Motor-Starting Switches: General Electric Company, Schenectady, N. Y. 4-p. technical data folder devoted to starting switches for fractional horsepower motors, with thermal overload protection (a-c, single- and double-pole; d-c single-pole). Also circular on a new oil- and heat-resisting insulated cable.

Motors: Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Well illustrated 12-p. bulletin giving complete information on thermo-guard self-protecting motors. In addition to describing the several types of these motors, motor protection, applications, control, etc., are discussed. Also a data sheet on combination line starters for squirrel-cage and wound-rotor induction motors and a leaflet on starting and speed-regulating rheostats for d-c motors.

Pipe Covering: Mundet Cork Corp., 450 Seventh Ave., New York City. Price and information bulletin on cork pipe covering for low-temperature piping, including data on installation when pipes are too close together for regular covering, specifications, ordering instructions, and sundries for cork covering.

Photo-electric Relays: General Electric Company, Schenectady, N. Y. 4-p. bulletin describing a photo electric relay (actuated by a beam of light) and giving examples of applications.

Pumps: Goulds Pumps, Inc., Seneca Falls, N. Y. 12-p. bulletin describing and illustrating in detail flexi-unit centrifugal pumps for capacities to 4,500 gpm and heads up to 350 feet. A series of pump selection charts is included.

Refrigerating Units: York Ice Machinery Corporation, York, Pa. 20-p. bulletin describing and carefully illustrating the construction of refrigerating units designed expressly for freon.

Regulators: Defender Automatic Regulator Co., St. Louis, Mo. Pocket catalog illustrating and describing flue-gas analyzers, combustion test outfits, gages, instrument boards, recorders, level controls, draft regulators, float and reducing valves, etc., of several types. Also a bulletin devoted to improved chronometer valves for hot or cold liquids and a bulletin on portable CO_2 recorders.

Valves: Barnes & Jones, Incorporated, 128 Brookside Ave., Jamaica Plain, Boston, Mass. 4-p. bulletin describing modulation valves (lock shield, wheel handle and chain-operated types) and giving dimensions and capacities. Drawings showing application of universal right angle and straight extension stems are shown.

Valves: Frick Company, Inc., Waynesboro, Pa. 12-p. booklet devoted to electric control valves for refrigeration plants, including design and application, illustrating various types, electric control valves as unloaders, methods of installation and wiring.

Valves: Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pa. 4-p. pamphlet describing automatic control valves for compressed-air lines and stressing their uses in improving the operation of pneumatic tools.

Welding: The Linde Air Products Company, 30 E. 42nd St., New York City. 16-p. booklet discussing oxy-acetylene welding for general maintenance, including sections on piping, tanks, sheet metal, process equipment, valves and valve ports, etc.

A 48-page paper-covered pamphlet, "The Visual Fatigue of Motion Pictures" has been published by the Amusement Age Publishing Co., New York City. Page size is 5x7; price, $1.00. It is a world-wide summary and survey compiled by Aaron E. Singer, and divided into the following sections: summary and recommendations, research reports, lighting, the eye, projection, education, ventilation, exhibitor, architecture, seating, screen. Ventilation is stressed as a most important factor.

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SITUATION WANTED—MECHANICAL engineer, experienced in air conditioning and refrigeration, sales, design and erection. Member A. S. H. & V. E. Address Key 209-A, "Heating, Piping and Air Conditioning," 1900 Prairie Avenue, Chicago.

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